Submission No 28

INQUIRY INTO ASPECTS OF AGRICULTURE IN NSW

Organisation: The Rural Block

Name: Mr Bruce Gardiner

Position: Farm Business Management Consultant

Telephone: 02 6721 9838

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Overview

Before we start...

- A sample of 500 NSW farmers involved in property management planning indicates that about 95% do not have the tools to objectively assess farm business performance in relation to financial, personnel, enterprise or land and water resources.
- Plans based on this low own-farm information base should be considered flimsy.
- 70% of farm businesses are not making a profit despite Australian farms trebling production in the last 40 years.
- There is no lack of information about Australian farm performance from outside the farm business. You probably have a lack of information about YOUR farm business.
- Don’t plan unless you intend to change this.

So, if you decide to start...

- Treat the **Cause** rather than the **Symptom**
- Focus on **Why** things happen as well as **How.**
- Many people focus their efforts on raising **Potential** (genetics, selection) when improving **Performance** (units of production per mm of rainfall) will give a greater return.
- Increasing throughput has not increased profits to Australian agriculture over the past 40 years. There is no reason to assume it will work now. **Production does not equal Profit!!!**
- Most people who start keeping paddock production records admit they were wrong about which paddocks were their best
- Measure the **Results** of what you do, but understand the **Consequences**

Your decisions make or break the farm business

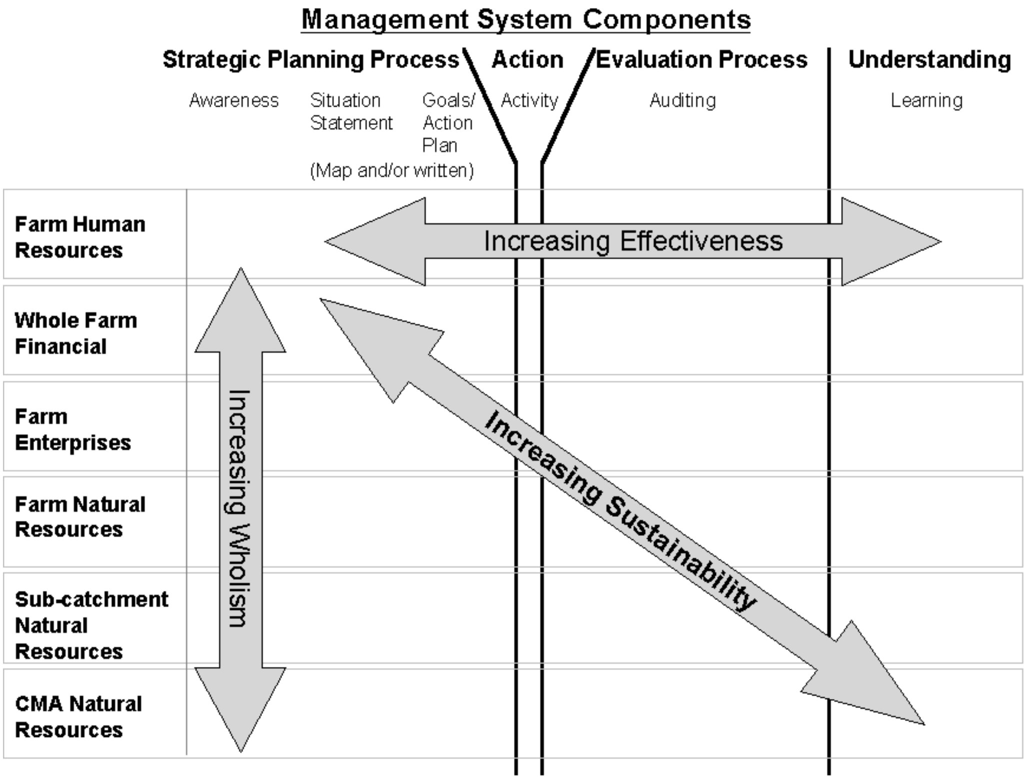
What are a PMP and a CMS?

Property Management Planning (PMP) helps fulfil part of the requirements of a management “system”. In the diagram below, PMP helps an individual complete the strategic planning process (awareness, situation statement, goals/action plan) from the farm human resources level down to farm natural resources level.

We make the distinction between decision making “processes” (which includes guessing, gut feeling, experience etc..) and decisions based on management “systems”. If there are components of the farm business where objective auditing of some relevant performance parameter does not occur, then a management system does not exist and a decision making process does.

We should also at this point make the distinction between “operational” level systems and “management systems”. Operational level tactics also carry the term of system. These may be grazing systems such as ‘rotational’ or ‘cell’ for example. Operational farming systems can be ‘direct drill’, ‘minimum till’ etc. Our take on this is that a effectively functioning “management system” would be able to objectively assess the benefits or disadvantages of a particular grazing or farming system and provide a framework for developing strategies to improve or replace these operational systems.

In the absence of a management system, operational systems often take on the status of a management system.



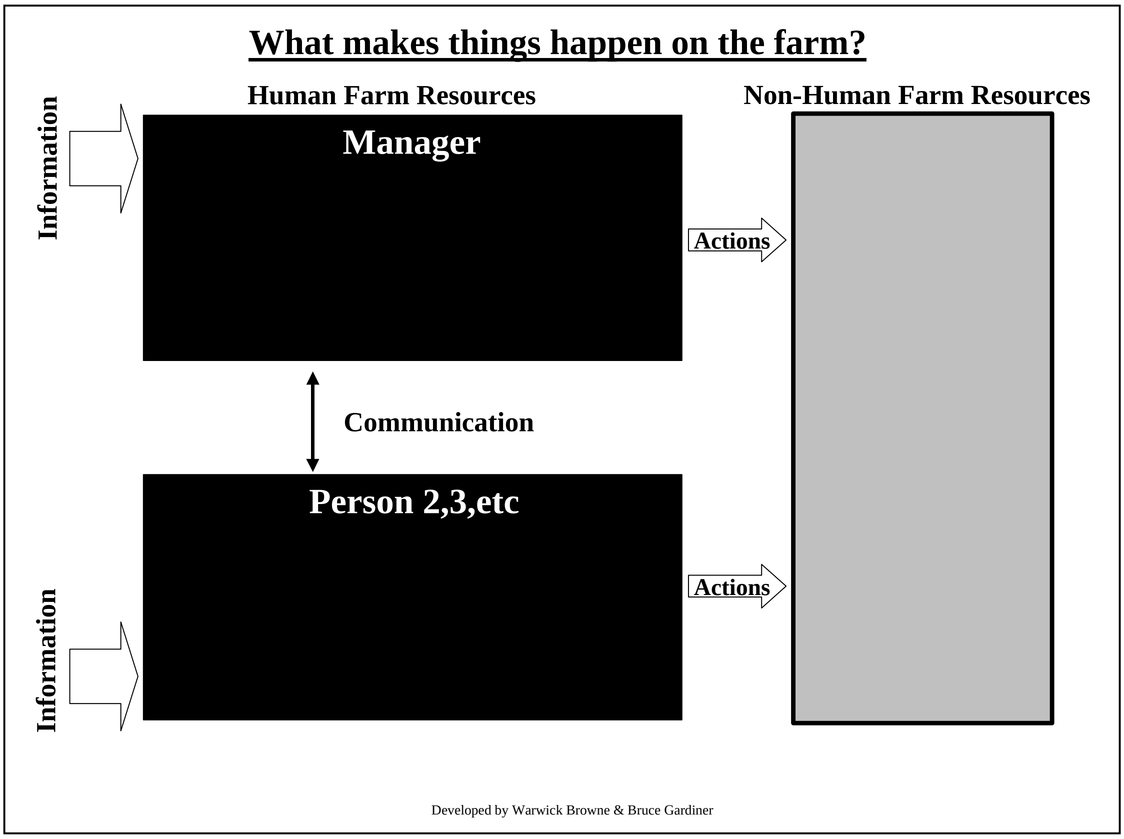
The evaluation process part of the management system is generally not implemented without assistance. CMS (Customised Management System) is the process we use to complete the management system after the completion of PMP. This is a dynamic and interactive process which creates individually tailored auditing procedures for each farm.

How do you decide what to do??

See the diagram below. Decisions are a function of information coming into the manager over time through things the manager sees, reads, smells, hears, does, touches. The decision the manager makes will result in;

a) no action,
b) the manager does something (an action), or
c) the manager communicates to someone else who does a, b or c.

Diagram 1 What makes things happen on the farm?



In most cases, what goes on inside the managers' head is a mystery. It is like a black box under the bonnet of a new car...things go in, the box completes an action and the car goes. What actually happens inside the box is known only to a few technicians. When the black box doesn't work, the car doesn't work. Get a new black box.

The farm owner/manager seems to be the same. Once information goes in, hardly anyone really knows what causes the resulting decision. Unfortunately, like the car, if the black box doesn't do the right thing, then the farm doesn't work properly either.

Luckily, we can learn more about the 'farmers' black box' so that we can do a bit of maintenance to improve its performance (although some wives would happily replace it with a new one).

Do all farmers make the same decision given the same information?

NO!!

Do all these decisions make those farm businesses more profit and improve the farm resources?

NO!! 70% of farm businesses are making a loss. Soil loss is on average at least 10 times soil formation rates. Salinity is increasing. Weed invasion is increasing. Farmer suicide, accident and divorce rates are high. Infrastructure and plant is rundown.

NO!! Nearly all want to look after their family and leave their land in better nick than when they got it.

Is that what farmers want??

Does it make sense to understand HOW and WHY a farmer makes a decision??

YES!!

The model below forms the basis for understanding how we can improve farmer decisions

The Farm Management Model

Diagram 2 Behavioural Agriculture

Behavioural Agriculture - Discovering "Why?"

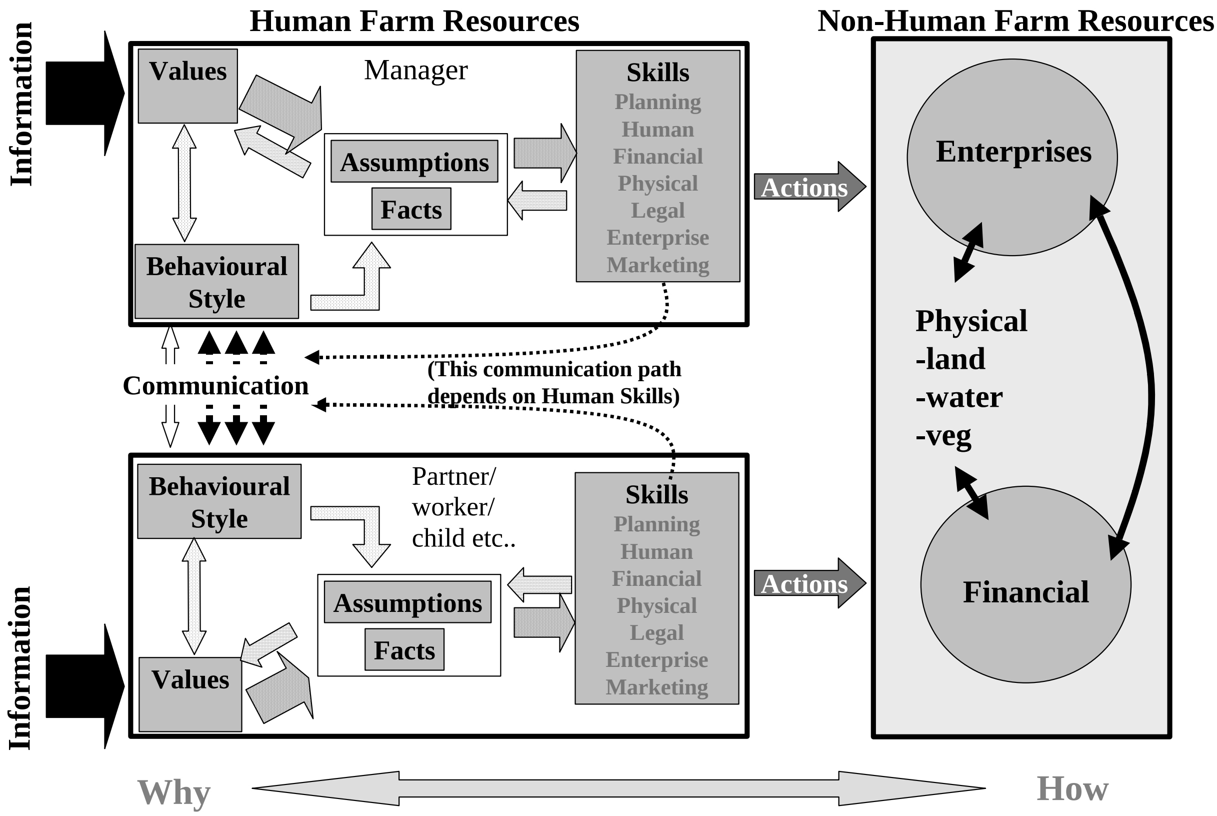
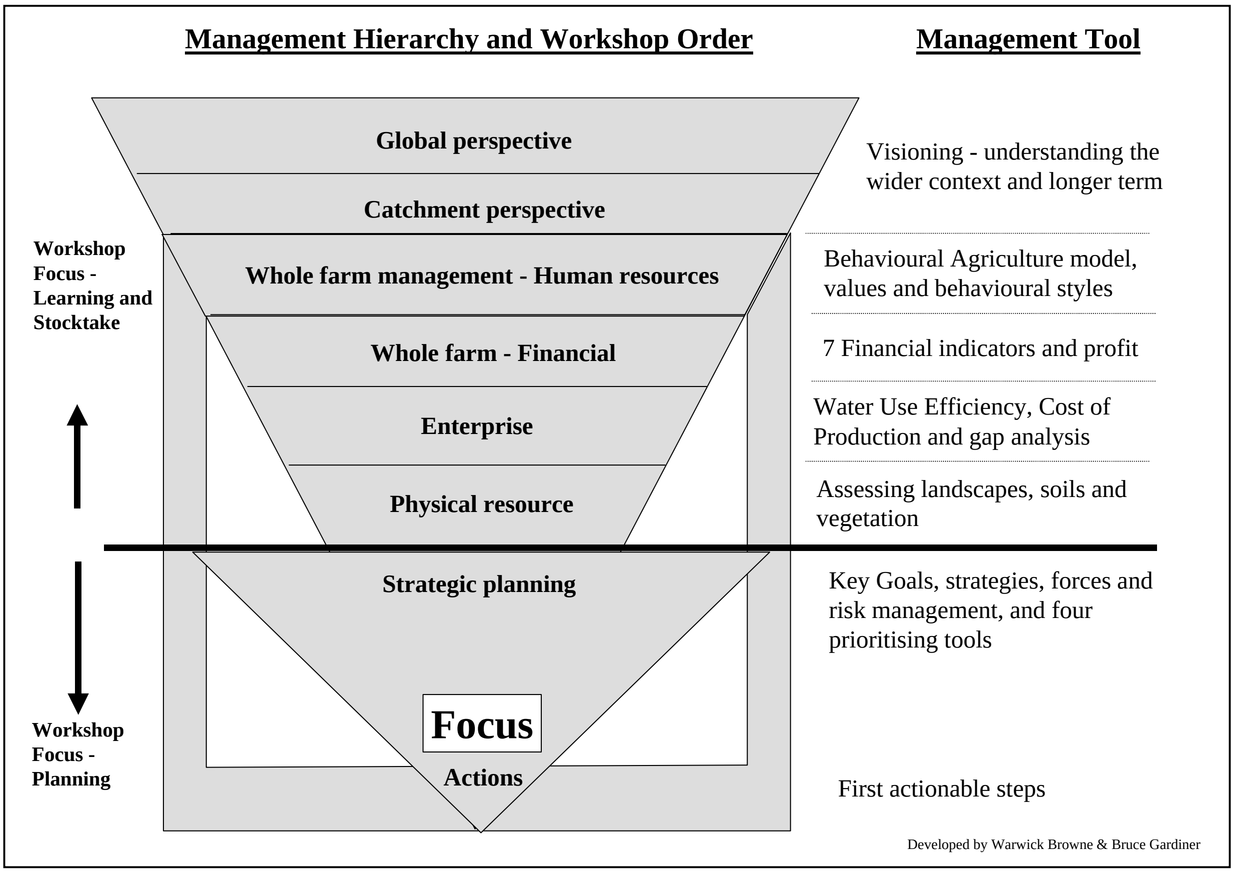


Diagram 3 The workshops and management hierarchy



The aim of the Workshop Series is to assess farm business health, understand 'why' it is this way, and develop steps to improve the situation.

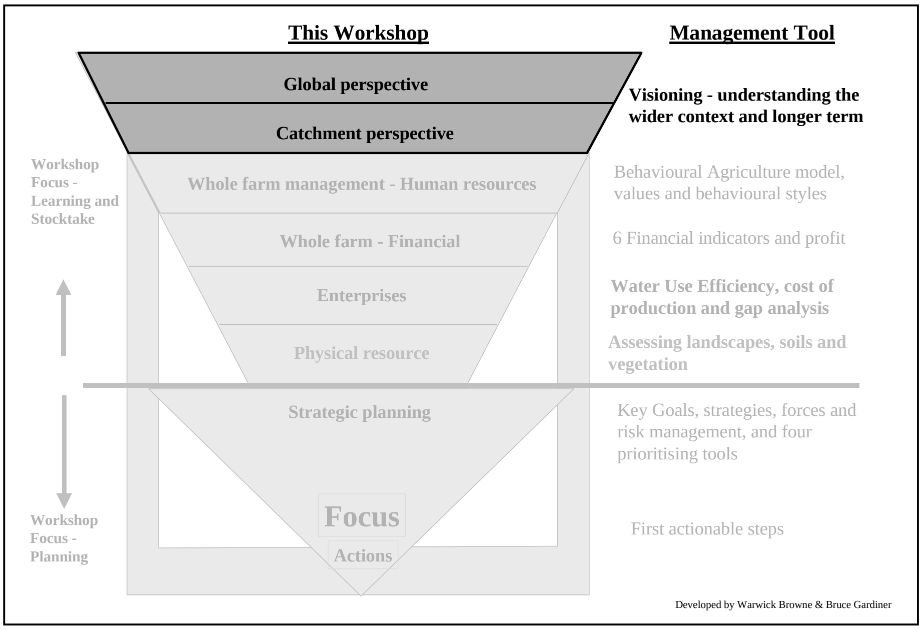
The diagram above describes the hierarchy of the different components of the workshop series and, correspondingly, the farm business. The order they will be addressed in is top to bottom, which usually moves the focus from symptom to cause.

From the farm business perspective, the success of each section depends on the success of the section below it. From the 'Whole farm – Financial' component down, indicators are used to quantify the performance of that component (listed alongside are some of the tools used for each component). Less than optimum results lead to further investigation in the section below it to identify the cause.

The 'Whole farm management – Human resource' component is seen as a framework within which the other components are managed. When trying to identify the 'causes', this component may provide the answers.

The Global and Catchment Perspective

Diagram 4 This Workshop



Background

Your farm does not exist in isolation from other farms – either in a physical sense or a financial one. Similarly, what happens in this state or region is connected to the rest of the nation. Also, what happens on the world stage has an impact on you and the resources you manage.

Increasing primary production is unambiguously "good" for the national economy because it leads to lower commodity prices and additional consumer surplus to stimulate growth in other sectors of the economy. As a result, agricultural sustainability and economic growth may become competing national objectives. The objective of this unit is to explore sustainable farm management decision making, not resolve the broader macro-economic policy issues, although there is a body of theory that shows that the two outcomes need not be mutually exclusive.

Over the past 40 years, ABARE's index of the volume of production has tripled in value, a testament to advances made by researchers and the adoption of these more productive technologies by farmers. This has had massive, positive economic consequences for Australia through its addition to consumer surplus. However, over the same time period, the trend real gross cost of production has doubled while the real gross value has remained virtually constant. Not surprisingly, the real net value (and profitability per farmed hectare) has fallen by 70%. Figure 1 below shows these changes, starting from a base year of 1965.

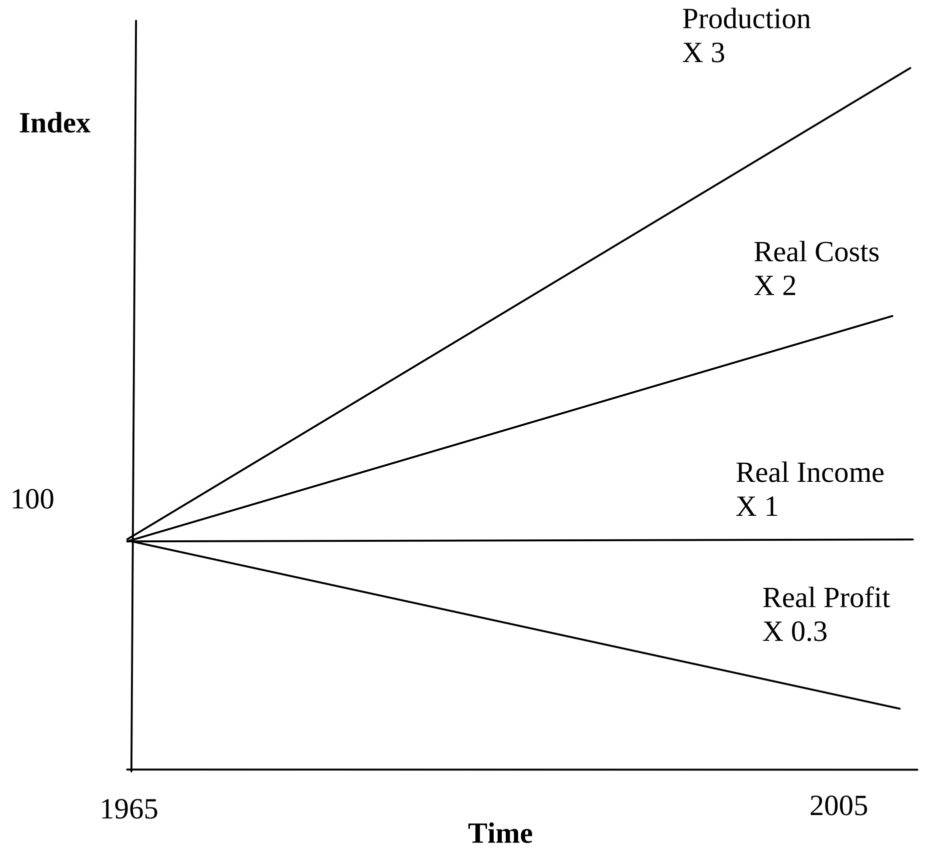


Figure 1 Trends in key farm performance indicators – 1965 to 2005.

Because Australian farming is characterised by numerous small producers, it is highly unlikely that the above trends are the result of a few spectacular successes or failures. They are more likely to be the result of thousands of individual production decisions that have not produced the desired outcomes for farmers. It is hard to accept the premise that farmers have taken deliberate decisions to reduce the profitability and sustainability of their businesses.

These trends raise some interesting issues for Australian agriculture. The relationship between productivity gain and farm financial performance is patently not positive. There is a good reason for this. Productivity gain is a component of supply side economics. Supply determines the minimum price (including profit margin) that producers will accept for a commodity. A slow mining of natural fertility is one “costless” way of lowering the cost of production. This is a feature of low rainfall rangelands management in Australia.

Competition between farmers (supply side economics) drives everyone towards the lowest common denominator. If this involves unsustainable natural resource management on the part of one farmer, it eventually flows through to all farmers if they wish to survive. Environmental degradation is more likely to be accelerated on more marginal land with higher production costs.

As productivity gains drive agriculture closer and closer to the margins of productive capacity, it takes increasingly smaller shocks to impact seriously on farm performance. As farm profitability falls, farmers are increasingly unable to survive such shocks from within their farm resources. Steady environmental, infrastructure and personal decline become entrenched farm management strategies for financial survival.

Demand side economics determines the profitability and sustainability of production decisions, particularly when there are hidden costs of production that are not incorporated into supply curve calculations

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Because the trend real gross value of agricultural production has remained constant for the past 40 years, we can make one important observation about equity within farming that has ramifications for the current native vegetation debate and the productivity focus of research and extension. Any extra income earned by one farmer has come from another farmer. In the absence of any evidence to indicate a change in these trends, one has to anticipate that any additional income made from land clearing on one farm will be offset by income losses on another farm(s). This observation holds true for any production enhancing management change and has important implications for the extension of small sample benchmarking and on-farm research to the broader agricultural context.

When the data used to calculate the above linear trends is further disaggregated, it shows that the most profitable five year period in Australian agriculture (in real terms) was 1962-3 to 1966-7, while the real gross value of agricultural production peaked around 1975-80. The index of the volume of production continued to rise to a peak of 113.9 in 2001-2. This clearly demonstrates that profit, income and production maximisation are sequential, not coincident. Management decisions to maximise one of these outcomes clearly precludes the capacity to achieve any of the others.

Because most of the costs of on-farm environmental decline are either ignored or transferred, the solution that maximises profit to the farmer under sustainable land management practices will occur at a lower level of production than that which maximises economic profit. This concept is critically important if sustainability is a genuinely desirable outcome. The most critical factor affecting farm sustainability in Australia is the long term, continuous decline in farm profitability.

Sustainability is an all or nothing concept. While it is possible, as will be shown later, to identify sustainable production outcomes for individual farms, this is ultimately doomed to failure in the absence of a commitment to sustainability at an industry level.

Demand for Agricultural Products

Figure 1 above clearly demonstrates that production, income and profit do not move in the same direction. This is consistent with the theory of linear demand curves for agricultural products and the marginal principles that determine profit, income and production maximisation.

The three key marginal principles are:

- Marginal revenue (MR) is the additional income produced from a change in production or management. MR = 0 when income is maximised.
- Marginal cost (MC) is the additional cost of the change in production or management. Profit is always maximised when MR = MC.
- Marginal product (MP) is the additional production achieved from an additional unit of inputs. MP ties the production side of the business to the financial side via the following mechanism. MR = MP x output price (Po) and MC = input price (Pi). Therefore, profit is maximised (MR = MC) when MP x Po = Pi or MP = Pi/Po.

Sustainability, profit, income and production are only maximised concurrently if the cost of all inputs, both market and non-market, is zero and demand for the product is price elastic. If either of these conditions is not met, some measure of sequential maximisation must be accepted.

As there is always some cost of production for a product, profit will be maximised at a lower level of production than income. If MC is positive, MR must also be positive. This can only happen if total revenue is rising. It also follows that, if Pi is positive then MP x Po must also be positive, which means that both MP and Po must be positive. MP can only be positive if the production function is upward sloping, i.e. production is increasing. If both income and production must be rising when profit is maximised, it follows logically that profit is maximised before either income or production.

If there are non-market costs of production, e.g. soil loss, greenhouse gases, etc, that are not accounted for as costs of production, the true MC will be higher than that specified above. The level of production that maximises profit under sustainable resource use will be lower than that which maximises profit under market conditions. Therefore, sustainability will be achieved before market based profit is maximised and, by extension, before income or production is maximised.

In the short term and at the individual farm level, income and production are maximised at the same time. Income is maximised when MR = 0, or MP x Po = 0. For any positive value of Po, income is maximised when MP = 0. As production is maximised when MP = 0, both income and production are maximised at the same time

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However, if price for a product is falling faster than productivity gain is increasing production, total revenue can be falling through time as production increases. This is always the case if the demand for a product is price inelastic. If demand is price inelastic, MR will always be negative and increasing production will reduce total revenue. Consider the following proposition. Total revenue (TR) = price (p) x quantity (q) or

TR = pq. MR is the slope of the TR curve with respect to quantity or
MR = dTR/dq. Fully differentiating dTR/dq gives
MR = p + q dp/dq. Factorising for p gives
MR = p(1 + q/p dp/dq). But q/p dp/dq is the inverse of price elasticity (E) and
MR = p(1+ 1/E).

Elasticity is defined as the slope of the demand curve (dq/dp) multiplied by price over quantity (p/q) at that point. Thus, with linear demand curves, elasticity changes along the demand curve even though the slope is constant

Because demand curves are negatively sloped, E will always be negative. Therefore, 1/E will always be negative. When demand is elastic, the absolute value of E is greater than 1, 1/E is negative and less than 1, p(1 + 1/E) will be positive and MR will be positive.

Conversely, if demand is inelastic, the absolute value of E will be less than 1, 1/E will be negative and greater than 1 and MR will be negative. Therefore, if demand is inelastic and production increases, TR will fall, proving that income is maximised before production. The relationship between demand, TR, MR, elasticity and quantity is presented diagrammatically in Figure 2, below.

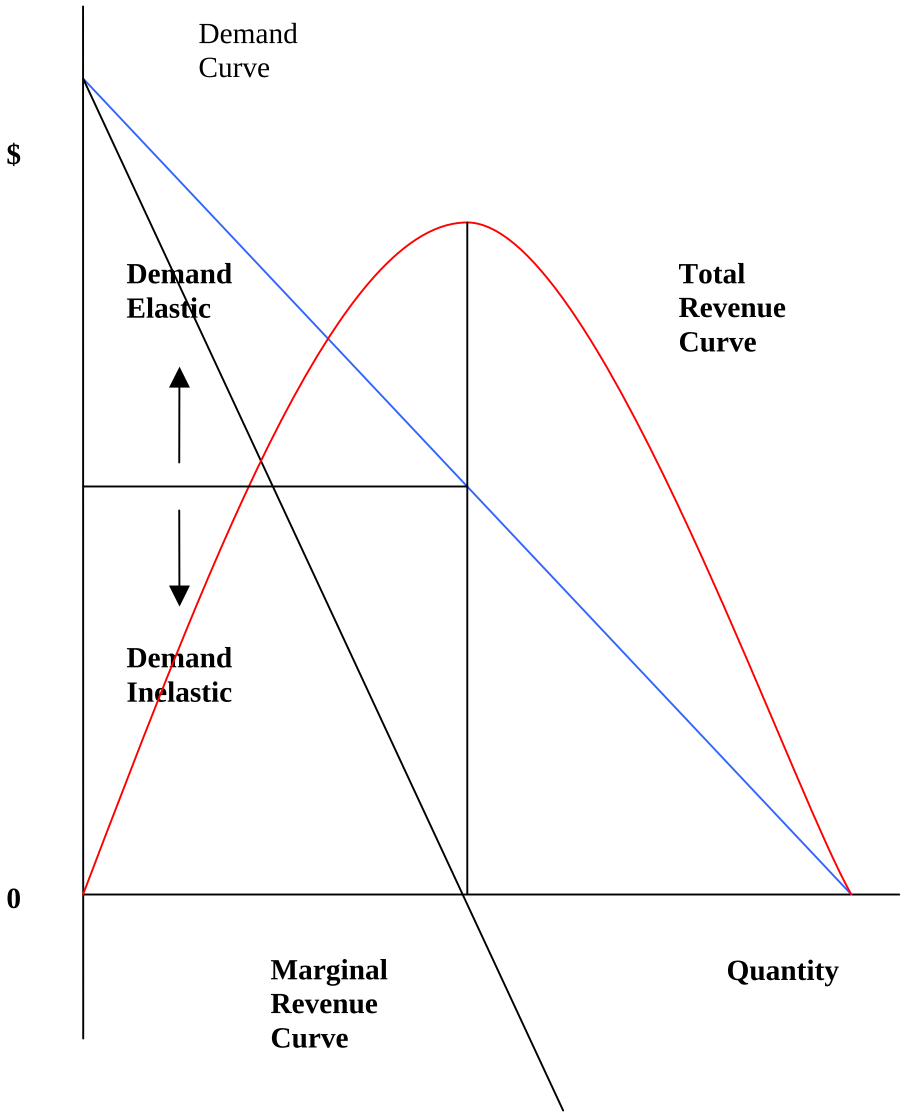


Figure 2: Relationships Between Demand, TR, MR, Elasticity and Production.

The following conclusions can be drawn from Figure 2:

- If demand is elastic, increasing production leads to increasing TR and declining, but positive, MR.
- If demand is inelastic, increasing production leads to declining TR and negative MR.
- TR is maximised when MR is zero and elasticity is -1, i.e. MR = p(1 + 1/E). MR can only be zero if (1 + 1/E) is zero or when E = -1.
- As long as MC is positive, i.e. there is some cost of production, profit can only be maximised when MR is positive and demand is price elastic. It should become immediately apparent to the reader that, even if all inputs are free, there is an optimal level of production that achieves sustainability and maximises both income and profit. There is no mechanism that prevents production from going beyond this point, i.e. production can continue to increase when demand is price inelastic. Thus, it is highly unlikely that production will be maximised at the same time as any of the other variables.

It is now possible to generate a likely sequence of outcomes from increased production, based on demand curves and marginal principles. This is shown in Figure 3, below.

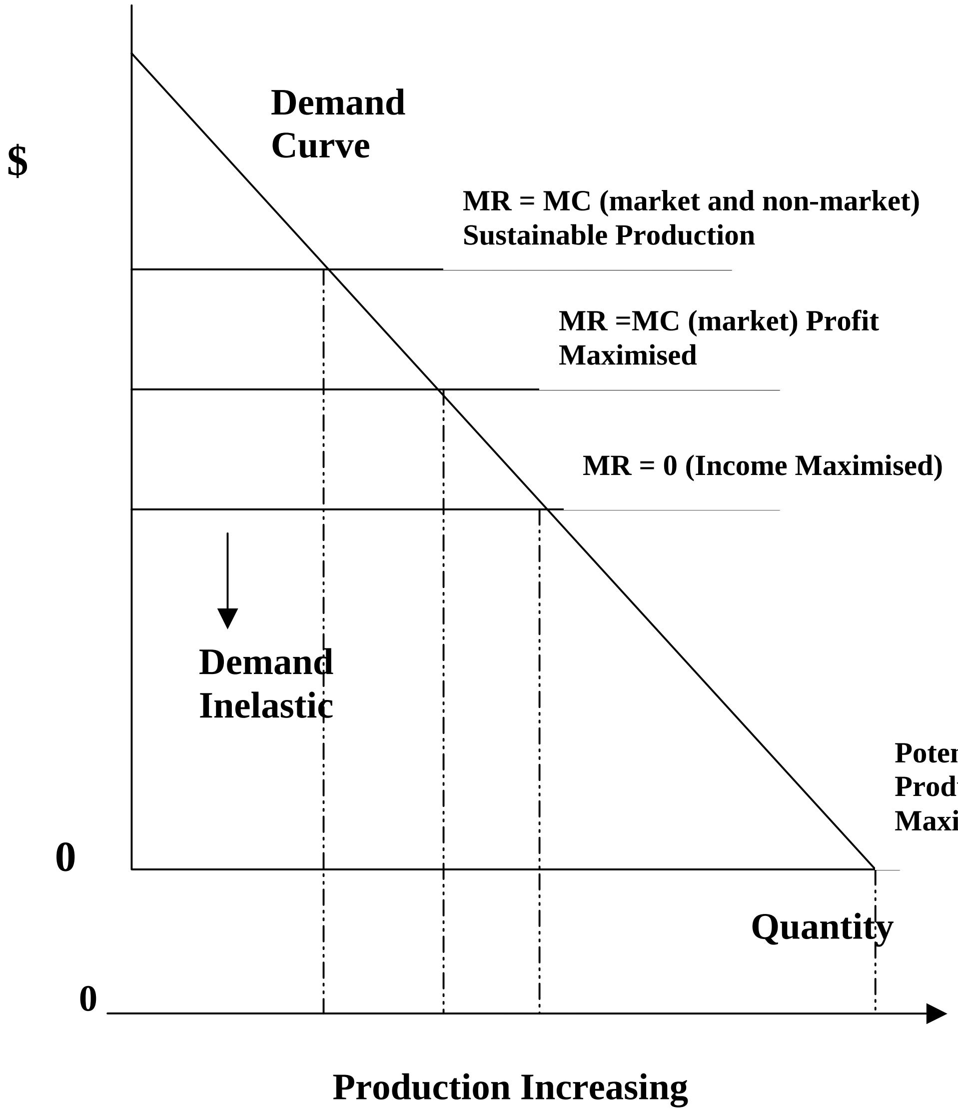


Figure 3: Sequential Achievement of Sustainability and Profit, Income and Production Maximisation

Marginal principles indicate that income is maximised when MR = 0 and profit is maximised when MR = MC. As long as there is a single cost of production, MC will be positive and profit will be maximised before income. If there are any unaccounted costs of production related to non-market factors, i.e. resources are used but not paid for, true sustainability will be achieved at a level of production less than that which maximises economic profit. Thus, there is a continuum of possible outcomes from production decisions, potentially ranging from the achievement of sustainability to the maximising of production, with profit and income being maximised sequentially along the way.

Because the demand curve is continuous, there are an infinite number of possible outcomes that might flow from producer's decisions. However, what is equally clear is that once a level of production has been determined, the solution, in terms of sustainability, profit or income, is unique. If the volume of product that is put on the market is that which maximises income to producers, it cannot be expected that that volume of production will maximise profit or be sustainable.

By extension, producers cannot expect to be sustainable if the demand for their product is price inelastic. It is important to recognise this fact when assessing the socio-economic impact of processes that may restrict an individual producer's capacity to increase production. It is also worth noting that, if demand for a product is price inelastic, there is an alternate solution that generates the same income, at a lower level of production, where the price elasticity of demand is 1/E, e.g. if producers are supplying to a market where the current price elasticity of demand is -0.5, they could make the same income by reducing production until the elasticity was -2 (1/-0.5).

There is a body of empirical evidence to suggest that the long run demand curve for agricultural products is of the form postulated in Figure 3. If Figure 3 is an accurate representation of reality, real income and profit should change in the following ways as production increases:

- Firstly, both profit and income should increase.
- Beyond this point, increasing production should lead to increasing real income but declining profit.
- There should be a third phase where, as production continues to increases, both income and profit fall.

Assessment of data for Australian agriculture for the period 1950 to the present shows that trend production has risen continuously, trend real profit increased until the mid-1960s and has been declining since and the trend real gross value of production, especially if exchange rate adjusted, peaked around the mid-1970s and has been declining since.

It is also possible to use price and quantity variability as a surrogate for demand elasticity. If demand is price elastic, quantity should vary more than price (a 1% change in quantity should be associated with a less than 1% change in price). Partitioning the data and calculating variance around trend shows that, between 1950 and the mid-1970s, production was more variable than price, indicating elastic demand. Since then, price has been more variable than production, indicating inelastic demand.

We can also draw on some recent examples. In the fat lamb industry,, between 2003 and 2006, production increased by 8%, while average price fell by 21%, implying an elasticity of 8/-21 or -0.38. Conversely, in the current year (2006), grain production is expected to fall by 40% while price has more than doubled, again implying an elasticity of about -0.4 (-40/100).

There is a school of thought that postulates that profit can be increasing while demand is inelastic and production is increasing. This requires that productivity gains drive costs down faster than the increased production drives prices and incomes down, i.e. MC is more negative than MR. This is commonly expressed in terms of supply being more price inelastic than demand.

While this idea is intrinsically appealing to those who seek to solve agriculture's malaise by productivity gain, it is inconsistent at both a philosophical and empirical level. Philosophically, if demand is price inelastic and productivity gains are used to increase production rather than reduce costs, total costs will remain unchanged (MC = 0) while total income will fall by p(1 + 1/E) times the change in production.

Consider the following example. Currently, q = 100, p = 1, E = -0.5 and cost = 90. Profit equals pq – cost which equals 100 x 1 – 90 = 10. Assume a costless productivity gain that achieves a 10% increase in production potential. If this is used exclusively to reduce costs, they will fall by 9% (10% of 91) to 82 and profit will increase to 18 (100 – 82). If any of the productivity gain is used to increase production, income will fall by -1 multiplied by the increase in production and cost will be greater than 81. Therefore, if income is less than 100 and cost is greater than 82, profit will be lower than 18, proving that cost reduction is the most profitable way to utilise productivity gain if demand is price inelastic. If the optimal decision framework is to maximise profit, utilising productivity gain to increase production is sub-optimal.

If the entire productivity gain was used to increase production, production would increase to 110 (100 x 1.1) and total income would fall to 90 (100 + (-1 x 10)). Minus 1 is the product of 1(1 + 1/-0.5) and 10 is the change in production. This is the additional income (MR) resulting from the management change. As there have been no cost savings, profit under this scenario would be zero (90 – 90).

The reader may satisfy themselves that utilising approximately half the productivity gain to increase production and half to reduce costs will result in the same level of profitability as that before the change (10).

However, if demand is price inelastic, the most profitable use of technology is to reduce costs with no increase in production.

At an empirical level, if supply is more inelastic than demand, real costs should fall faster than real income and the real net value of production should rise. Trend estimates for real costs, income and profitability indicate that costs are rising faster than income and, as a result, profit is falling, implying that, in general, supply is more elastic than demand. There may be some instances, e.g. the sheep industry, where supply responses may be corrupted by joint products. The current supply response to wool prices may be modified by the high value of lamb and mutton, i.e. apparent inelastic supply responses to wool prices may, in fact be highly elastic supply responses to the joint products. The long term move towards non-wool sheep (e.g. dorpers) and cattle in the traditionally wool producing rangelands may be an indicator of relatively high supply elasticity in the long term.

Agriculture in the Global Market

At the latest round of WTO talks, free trade in agricultural products was espoused as a solution for the lack of economic growth in less developed countries. The underlying theory of international trade suggests that comparative advantage allows different economies with different resource endowments to become more efficient at producing different outputs. Because all economies are not uniformly endowed, they will specialise in the production of goods and/or services that reflect their relative resource mix. International trade increases economic efficiency by enabling countries to specialise in their area of comparative advantage, rather than trying to be self sufficient in goods and/or services which, for them, are relatively expensive to produce.

As long as there are markets for all the inputs and outputs that go into producing a tradeable product, this process will lead to maximum efficiency in resource use. However, when there are market imperfections, the benefits are less clear cut. There are five important issues to be considered when assessing the benefits of world trade:

- The net value of world trade is always zero. By definition, exports must equal imports, i.e. everything exported from one country is imported by someone else. Thus, world trade is a vehicle for redistributing wealth not generating it. There is no logical, theoretical reason to suggest that this redistribution will be ethical, i.e. that it will transfer wealth from wealthy countries to poor countries. There is no evidence to suggest that the share of global wealth in the world’s poorest countries is growing. They are, in fact, becoming relatively poorer.
- The principle benefit from world trade is efficiency gain. Efficiency gain enables consumers to consume more with the same income. Given the problems arising

from our current level of consumption, it is debatable whether increasing consumption is a sustainable proposition.

- The demand for primary products is always more inelastic than that for the processed goods manufactured from them. This means that price falls resulting from an increase in primary production will be greater than those for the processed product. If global demand for the primary product is price inelastic, an increase in production can lead to a fall in real income, leaving countries that are reliant on primary exports relatively worse off. For example, the real gross value of global wheat exports has fallen by 40% over the past 25 years despite (or, perhaps, because of) a 20% increase in supply. Resource rich economies may be at a serious disadvantage if their resources are mostly exported and the capital necessary to develop them is imported.

- Comparative advantage may be achieved by non-sustainable means, e.g. in agriculture, it may be achieved by over-clearing, irrigating unsuitable land or using land beyond its long term, sustainable capability. Countries may exploit labour to lower costs, e.g. the Rwandan government legislated the use of slave labour in the coffee industry to give it a price advantage, a move applauded by the World Bank. Developed countries use capital to counteract cheap labour in competing countries, leading to such problems as acid rain, global warming, ozone depletion and resource exploitation in poorer countries. The consequences of such economic choices often fall disproportionately on poorer countries, raising ethical issues such as lack of compensation for global warming induced climate change.

- Issues of national security in food and manufactured goods may over-ride economic efficiency as a national policy objective. Protection of these industries may provide the “best” outcomes. Bio-security is a commonly used non-tariff barrier to free trade.

If global competitiveness requires non-sustainable resource management decisions, is international trade really in the national interest? If sustainable resource use requires some level of national income transfer (protection), is that necessarily “bad” from the perspective of economic efficiency? If economic efficiency is being bought at the expense of the natural environment, it may be more efficient to transfer income, rather than try to achieve the same outcome through global trade.

Free trade works if it is truly free, e.g. the market, not politicians, determines how much bio-security it wants and all producers are made accountable for those non-market costs for which they should bear responsibility, e.g. land degradation and greenhouse gas production.

Optimum Versus Equilibrium Production

The concept of optimal production relates to the proposition that there is a "best" level of output from any farming operation. In a purely economic sense, this is the level of production that maximises profit. This is the hurdle at which most plot and/or small sample experiments fall. While some effort is usually directed towards calculating which of the trial production systems is the most profitable, researchers commonly neglect the important step of determining whether there is an alternative input/output combination that has not been trialled that may be more profitable than any of the trialled combinations, i.e. optimal.

When economists discuss equilibrium, they mean the point of intersection of a demand and supply curve. At this point, the volume of production placed on the market will be cleared at that market price. Because of the relatively long time frames involved in converting production decisions into actual production, current supply will be determined by price in some previous period, e.g. many tree crops have a five year gap between planting and production. The high level of capital investment in many agricultural enterprises may also mean that producers are locked into that enterprise for a long period of time, irrespective of current market conditions, e.g. the wine grape industry.

Conversely, market price is determined by the volume of product currently available. There will be factors outside the control of the producer, e.g. climatic variability, that lead to differences between actual and planned output. The combination of the above factors means that planned and actual outcomes will rarely be the same.

It is also worth noting that economics is concerned with the efficiency of resource use. Resources will flow to those producers who can combine them in the most efficient way. This superiority of resource combination is known as comparative advantage. Efficiencies allow some producers to bid a higher price for their inputs and sell their output for a lower price and still generate sufficient profit to remain in production. The cost of inputs and the price of output will be determined by the most efficient producer.

This process works well if there are efficient markets for all inputs and outputs. Many of the inputs into agriculture are non-market goods. The competitiveness of some farmers may be a function of a more benign climate and inherently more fertile soil, but it could equally be a function of their capacity to mine the natural resource base. Thus, in an economic sense, degradation and efficiency may be the same thing.

Equilibrium is about constrained optimisation, where the constraint is the activities of all other farmers. While optimising is about achieving the best result, equilibrium is about doing as well as possible under the circumstances. If comparative advantage in supply is achieved at the expense of the natural resource base, it may entrench poor land management decisions in all farm systems.

The above analysis relates to aggregate and industry level economic assessment. However, production economics allows us to prove that the same conditions apply at the individual farm scale.

Economics of Sustainability and Productivity

The analysis of the individual farm case presented below is based on Earl O. Heady's "The Economics of Agricultural Production and Resource Use" which covers most areas of production economics.

Henderson and Quandt (Micro-economic Theory, p.54) state that “the best utilisation of any particular input combination is a technical, not an economic, problem. The selection of the best input combination for the production of a particular output level depends upon input and output prices and is the subject of economic analysis.”

Declining terms of trade in agriculture is often quoted as a cause of poor farm financial performance and as a reason to pursue productivity gains and economies of scale. Terms of trade measures the relative difference between the price of outputs and the cost of inputs. There is no logical reason that makes a decline in this measure inevitable. It is relatively easy to conceive of cases where terms of trade could, in fact, be increasing. Declining terms of trade is a symptom of a dysfunctional management system that fails to recognise pricing mechanisms in input and output markets. If productivity gains are causing prices for outputs to fall faster than the cost saving associated with more efficient resource use, declining terms of trade is the measure of, not the reason for, worsening financial performance.

Not only is declining terms of trade used to validate the search for productivity gain, it also adds credence to the concept of economies of scale as a way of survival as margins are squeezed. Increasing the scale of an operation is only the solution if lack of scale is the most limiting problem faced by the business. As long as declining terms of trade is viewed as an immutable law of nature, economies of scale are a self fulfilling prophesy. The sooner we are prepared to accept that there may be alternative ways of doing business that can reverse the current trend in terms of trade, the sooner we can dispose of the dogma surrounding productivity gain and economies of scale. I am not suggesting that we do not search for productivity gains. I am merely suggesting that those productivity gains are used effectively to improve the economic and natural resource conditions on Australian farms.

It is critically important that farmers recognise that it is not possible to maximise sustainability, profit, income and production at the same time. This is easily proven theoretically and empirically. Consider these three propositions:

- There are some costs to farming that are not accounted or paid for by farmers in a financial sense e.g. soil loss.
- There are costs associated with the production of any agricultural product e.g. variable and fixed.
- The demand for agricultural products is price inelastic i.e. a 1% increase in production leads to a more than 1% decline in price.

The acceptance of these three propositions is sufficient to prove that sustainability happens first, followed by profit, income and production maximisation, in that order. Why is this so??? The implications of the first two propositions are demonstrated in the diagram below (Figure 4).

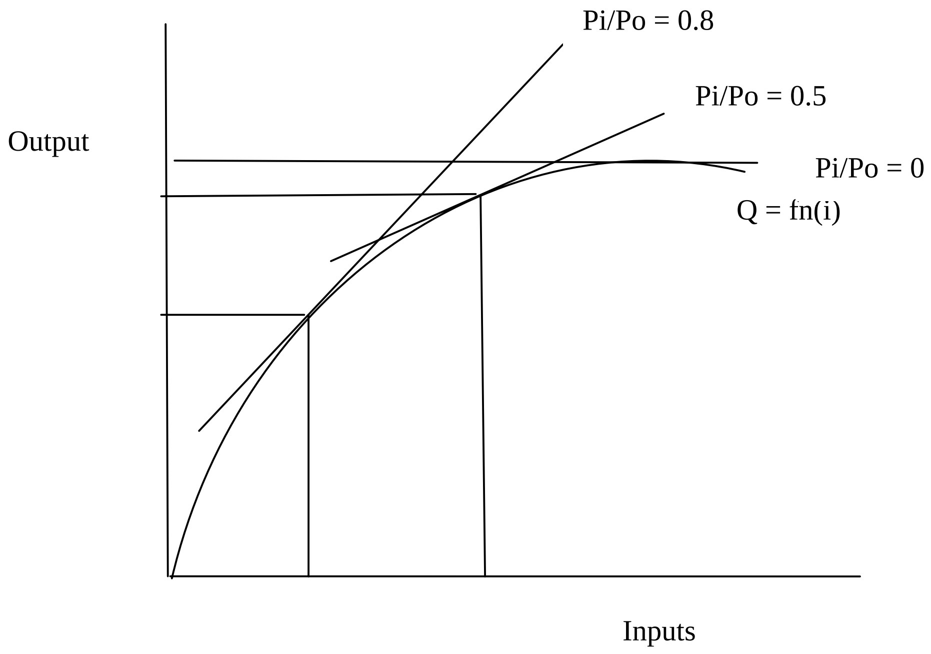


Figure 4 Relationship between a production function, the prices of inputs and outputs and profit maximisation.

Q = fn(i) is the functional relationship between the volume of inputs and the volume of output for a particular farm product. All farmers are faced with a production function similar to this for each of their enterprises. Over the rational range of the production function, there is an infinite combination of input and output options, ranging from zero to maximum production. However, once a decision has been made about a certain combination of inputs and outputs, that solution is unique and mutually exclusive. As long as the production function is unchanged, the same combination of inputs will achieve the same level of output. For example, it will be shown that it is not possible to maximise production and profit at the same time. If management decisions are targeted at maximising production, the only outcome will be maximum production. **Producers must understand that optimum production and maximum production is not necessarily the same thing.**

Pi/Po measures the ratio of the price of inputs to the price of output. Profit is maximised when marginal product (MP) equals this price ratio (where a line with slope Pi/Po is tangential to the production function). In the above example, when hidden costs are ignored, Pi/Po=0.5 and profit is maximised where the slope of the production function is also 0.5 i.e. one unit of inputs produces 0.5 units of output. This is also the point at which marginal revenue (MR) and marginal costs (MC) are equal via the following logic:

- MR equals MP*Po (the additional production attributable to an additional unit of inputs multiplied by the product price)
- MC equals Pi (the cost of the additional unit of inputs)
- To maximise profit, MR = MC or MP*Po = Pi
- Dividing both sides of MP*Po = Pi by Po gives MP = Pi/Po and profit is maximised.

Sustainability

When hidden costs are accounted for, Pi goes up and Pi/Po rises to 0.8, giving a new optimal solution with a lower use of inputs and a lower level of output. The optimal output for sustainable production is always lower than that which maximises economic profit. As hidden costs are accounted for in an economic sense, sustainable and profit maximising output coalesce at this lower level of production.

It is important to note that sustainability is a mutually exclusive proposition. Management decisions have outcomes that are either sustainable or not. It is possible to have a range of not sustainable outcomes from just about sustainable at one end to total degradation at the other. The fact that a practice is less not sustainable does not make it less totally degrading in the end. It just takes a bit longer to get there. Maintaining environmental amenity (sustainable production) is a cost against the farm business, even though it may be a non-cash cost.

Productivity and Profit

The above methodology is generalised and based on the premise that the rate of change in output relative to changes in inputs, and the prices of inputs and output are easy to measure temporally. It obviates the need to understand the rate of technical substitution between inputs and the rate of product transformation between outputs. Conversion to the multi-input, multi-output case provides the same set of answers. To maximise profit, each input is utilised up to the point where its marginal product in the production of each output equals the ratio of the price of that input to the price of the output i.e. $MP_{n,j}$ (the MP of the nth input relative to the jth output) = P_n/P_j.

It is not possible to determine the optimal level of output from a production function in isolation. The profitability of production decisions based on productivity gains depends on what happens to Pi and Po as a result of those decisions, not the technical relationship between inputs and outputs. The amount of production that maximises profit is always determined by the ratio of Pi to Po.

While it is not possible to generalise about the relationship between productivity gain and profitability from the available economic theory, it is possible to measure the impact on profitability of farmer's decisions based on productivity gains from an historical context. The available data show that farm profitability has fallen by 67% over the past 40 years despite a 2% to 3% per year productivity gain. The implication is that Po has been falling faster than the rate of efficiency gain induced decline in Pi.

Farmers' terms of trade, as recorded by ABARE, are the inverse of Pi/Po (Po/Pi). Taking the inverse of the terms of trade index, the slope of Pi/Po has changed from about 0.45 in the 1960s to around 1 in the last decade. This is analogous to the situation shown for hidden costs in Figure 1.

This does not mean that we stop looking for technologies that increase productivity. What it does mean is that we must be more selective in the way we utilise these new technologies. For example, a new technology increases yields by 10% from the same suite of inputs. It is applied to all existing production areas but this increase in production leads to a 15% decrease in price. Are producers better off? The more rational approach may be to utilise 10% less area, to minimise the impact of inelastic demand on product price. Utilising technology to reduce the area, rather than increase the volume, of production will continue to be the most rational response as long as real costs are rising faster than real income (demand is more inelastic than supply).

Production and Profit

Acceptance of the second proposition must lead to acceptance of the premise that profit is always maximised before production. Production is maximised when marginal product is zero. For profit to be maximised at the same time as production, Pi/Po must equal zero. This solution can only happen when Pi equals zero (when all inputs are free). By substitution, MP = 0 and MP*Po = MR = 0. As profit is maximised when MR = MC, then MC = Pi = 0. This scenario is shown in the Figure 4, above. As long as there is a single cost of production, profit will be maximised first. Combining the two propositions can only lead to the conclusion that sustainability is achieved before economic profit is maximised and profit is maximised before production is maximised. Thus farming systems aimed at maximising production or economic yield cannot achieve sustainability.

Production and Income

Acceptance of the third proposition implies that income is maximised before production. If demand is price inelastic, a 1% increase in production will be offset by a more than 1% decline in price. Conversely, a 1% decline in production will be offset by a greater than 1% increase in price. Every major agricultural economics textbook written since the 1960s has identified inelastic demand for agricultural output as the primary reason for the declining profitability of farming. This inelasticity is confirmed by a plethora of empirical studies of demand curves for agricultural products. Fitting a linear trend to ABARE indices of the volume of production and prices received by farmers in Australia for the past 43 years gives a function, Q = 150 – 0.4P, where Q is the volume of production index and P is the prices received by farmers index. This produces a current price elasticity of demand for all agricultural output of between -0.3 and -0.4. Elasticity is the slope of the demand curve (-0.4) multiplied by the price index divided by the production index for the current year (this has ranged between 0.8 and 1 in the recent past). There have been 3 notable outliers in the data series when international events have had a major impact on the viability of Australian farms, all related to low grain stocks. For the other 40 observations, the global impact has been essentially neutral. If income can rise as production falls then it is logical to conclude that income will be maximised before production is maximised.

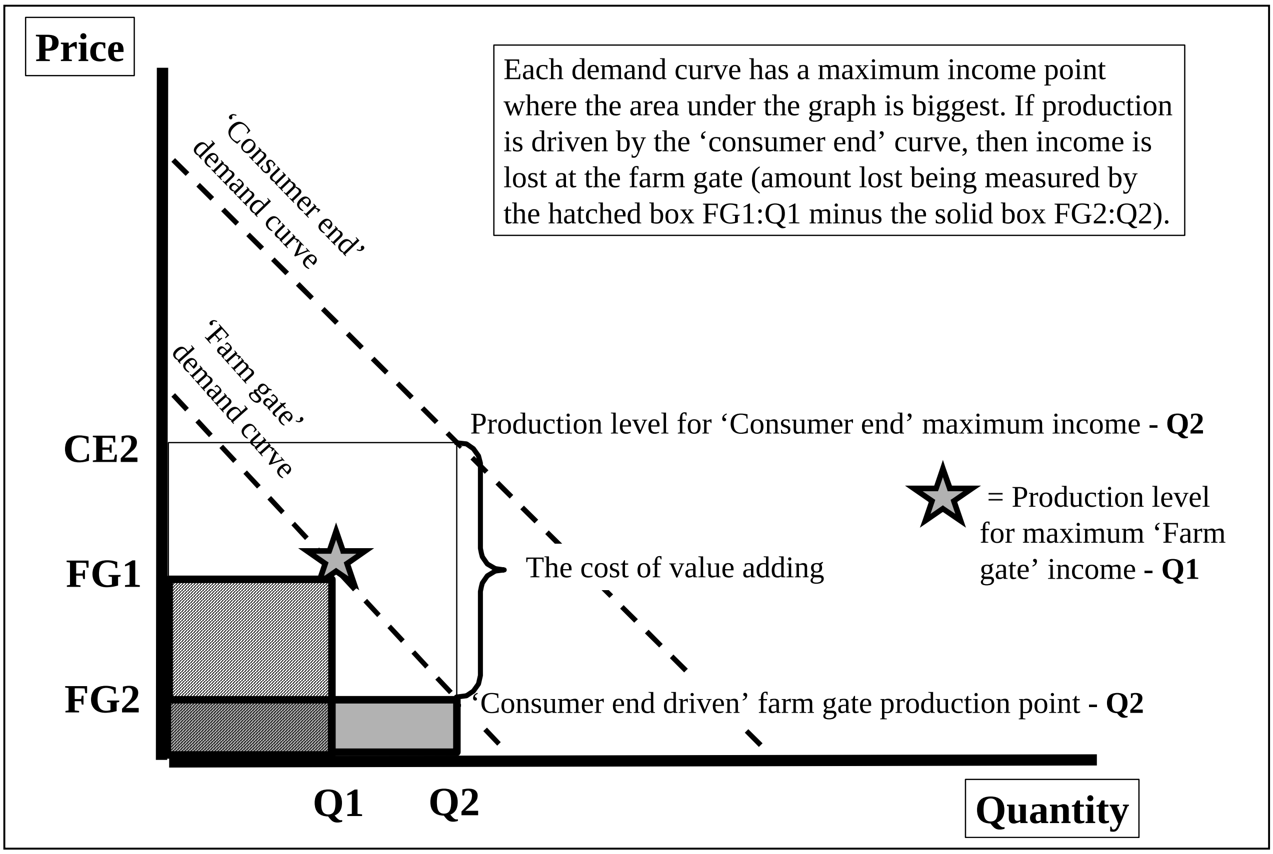
Acceptance of these three propositions then clearly demonstrates that sustainability will be achieved at the lowest level of production, followed by profit, income and production maximisation in that order. Management practices which have a focus on maximising productive potential are unlikely to be sustainable in the long term. If achieving long term sustainability is a desirable outcome then those involved in all facets of agriculture will need to shift their focus from its current emphasis on production and productivity gain marketed on its ability to increase production to one where the natural resource is used within its sustainable limits.

Is Sustainable, Profitable Primary Production in the National Interest?

It is interesting to contemplate the apparent reasons for our existing love affair with productivity gain. It is relatively easy to demonstrate that increasing the volume of agricultural output does not benefit farmers. However, as stated earlier, increasing agricultural production is unambiguously good for the national economy. This is because declining real prices for agricultural products adds to the amount of income consumers have available for consumption of other goods and services, especially if real incomes are rising. Final consumer demand measures GDP (Gross Domestic Product). Just as farmer income is maximised when farm gate demand elasticity is -1, so too is GDP maximised when final consumer demand elasticity is -1. This is shown in Figure 5.

Farm gate demand (price) is determined by the price that the consumer is prepared to pay minus the costs of converting the primary product to a form and location that has value to the consumer. Because the final consumer demand curve is above the farm gate demand curve, the volume of primary production necessary to maximise GDP is greater than that which maximises farm incomes. Economy managers have a vested interest in promoting productivity growth in primary industries. At a macro- level, national economic imperatives and sustainable primary production may be mutually exclusive.

Figure5 Demand Curves for Agricultural and End Use Products



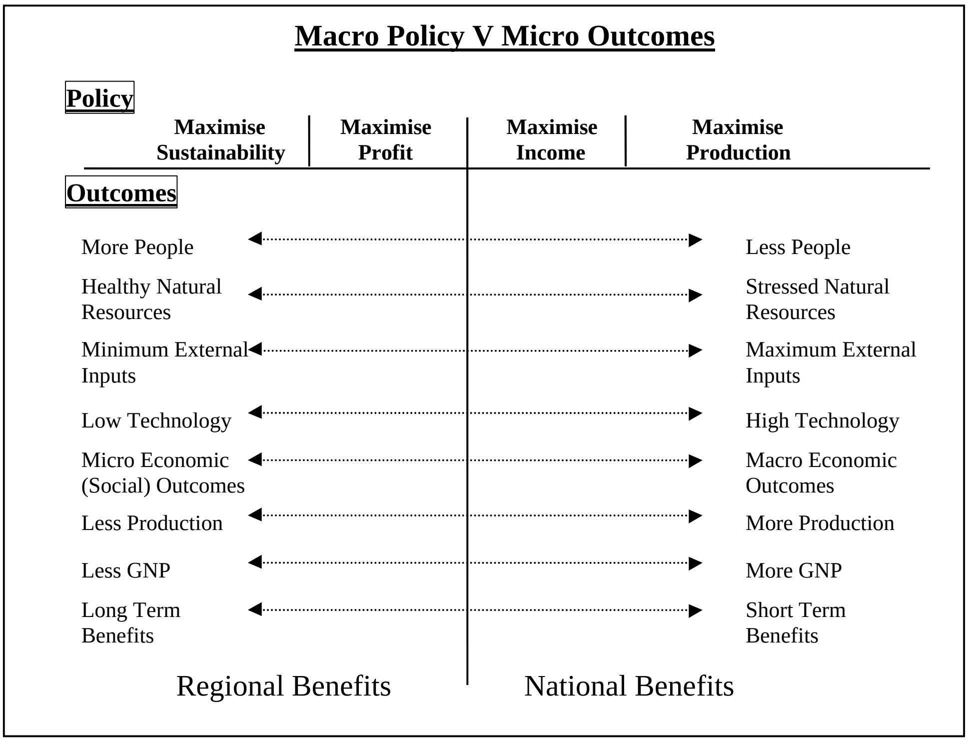
Countries that are net importers of primary products can purchase their consumer surplus in the international market. Exporters of primary products are also large exporters of consumer surplus because of the loss of any value adding, e.g. Australia exports coal and iron ore at low prices and imports steel and steel manufactures at high prices. It takes many times the cost of the raw materials to purchase the finished product, i.e. we must export a volume of raw materials that is greater than that required to manufacture the finished product to generate the same amount of consumer surplus. More elastic demand at each successive stage of resource transformation is sufficient to guarantee this.

Many of the Research and Development Corporations and Industry Lobby Groups are funded by levies on agricultural production, usually on a unit of production (head, tonne) basis. If this is the case, such organisations have a vested interest in promoting increased production to generate income for the organisation. Such R&D corporations and farm product organisations tend to focus on short term productivity gain rather than the longer term, fundamental, economic research required to maximise profit for their client group.

Below is an outline of the likely impacts of focussing national policy on particular targets within agriculture. The financial resources section will help explain that these policies are a continuum and do not necessarily exist together.

Macro Policy v Micro Outcomes

Diagram 5: Policy and Outcomes



Some Notes on Sustainability

Ecologically Sustainable Development (ESD):

- Weak Definition of Sustainability (Brundtland and UN) – The total value of capital, both natural and man-made, should not diminish, i.e. any loss of natural capital should be off-set by an equivalent increase in man-made capital. Thus, a depletion of fish stocks (overfishing) could be off-set by an increase in the value of fishing boats.
- Strong Definition of Sustainability (Daley and others) – The rate of resource use should not exceed its capacity to recover to pre-harvest volumes between harvesting events, e.g. soil loss should not exceed soil formation rates.
- Triple Bottom Line – Many definitions of sustainability, implicitly or explicitly, express the need to sustain economic viability, society and environmental integrity. Sustainability can only be achieved if all three criteria can be met. Issues of scale, time frame, income transfer and an inability to achieve all three simultaneously need to be addressed.
    1. Should each individual resource user be sustainable or is regional, national or global sustainability sufficient? Can over-utilisation of a resource in one area be offset by under-utilisation of the same resource in another area, if the net impact is zero or positive?
    2. Is it possible to stage resource use such that periods of non-sustainable use are followed by periods of resource recovery, e.g. fish stocks?
    3. Is it possible to transfer income from resource consumers to resource producers to achieve better NRM? Sustainable resource use may only be

economically and socially viable with income transfers from consumers to producers.

4. If it is impossible to achieve a triple bottom line outcome, how do you deal with economic and/or social issues?

Utility and Disutility in the Measurement of Economic Growth

At least some of the variables that are currently used to measure growth (GNP) are costs associated with non-sustainable resource use or environmental degradation, e.g. the cost of cleaning up fuel and chemical spills. There is a growing acceptance amongst economists that the costs of repairing problems created by excessive resource use should be debits in national accounts rather than credits. Using such accounting protocols, GNP in most first world economies would have been falling since the mid-1970s. This would be doubly true if the impacts of global warming, acid rain and other environmental consequences of human economic activity that have not, to date, been costed, were added to the equation. For example, 16 million ha of coniferous forest in Canada is under threat from the pine beetle as a result of global warming. The lost value of this timber is not counted as a national cost and any expenditure on beetle control is counted as income!! Other interesting anomalies include waste disposal, e.g. is the cost of storing long term radioactive waste really a positive for GNP?, health issues arising from over-consumption, e.g. diabetes and obesity, and the cost of the climate changes generally attributed to global warming, e.g. increased fire and storm damage.

Interpreting Broad Scale Landscape Management

Drainage lines perform the same role in the landscape as the circulatory system in humans. All the by-products of our land management end up in the drainage lines just as all the by-products of our lifestyle end up in our circulatory system.. If the streams are relatively stable and the water quality is good, the catchment landscape will be in good condition, i.e. management practices across the catchment are likely to be sustainable.

If there are signs of active erosion of the stream bed or banks, this usually indicates higher peak flows, generally caused by management practices that produce increased run-off, such as soil structure decline or low ground cover. Turbidity and nutrient loads in water also increase as the speed of run-off increases, the erosive capacity of water being the cube of its velocity, i.e. a doubling of speed produces an eightfold increase in sediment carrying capacity. Checking the turbidity of peak flow as it enters and leaves the property can provide a measure of the sustainability of land management practices. As most nutrients are attached to clay particles, an increase in turbidity usually means an increase in nutrient load.

Different soil types become stable at different grades, i.e. some soils erode at lower water speeds than others. Stream geometry tends towards stability by increasing or decreasing stream length over a given grade. This is achieved by increasing or decreasing the radius of the meanders formed by the stream. If run-off is increased, i.e. run-off velocity increases, the stream will increase the radius of its meanders until water velocity falls to a stable speed for that soil type. It has been estimated that 90% of the nutrient load in stream water comes from bed lowering or bank erosion.

Landscape Resilience

This is about the frequency, duration and amplitude of processes that impact on natural resources and takes two separate concepts into account. Firstly, resilience measures the capacity of the landscape to recover from disturbance. Disturbance can take many forms. Changing from grazing to cropping is an obvious example. The greater the number of years of cropping, the longer it takes for the ecosystem to return to its pre-cropping state. If the cropping has reduced the total soil organic carbon level, the system may never return to its pre-cropping productivity. The factors that affect resilience are the amplitude of the disturbance, i.e. how seriously is the natural resource damaged by the disturbance, the duration of the disturbance event, the frequency of disturbances and the elasticity of the natural resource, i.e. the range of landscape attributes that can buffer the impact of the disturbance and reduce the time taken for the recovery process to be completed.

Landscapes with low slope, inherently more fertile soils and higher rainfall are likely to be more elastic than those with poorer soils and lower rainfall. If the recovery phase is long term, e.g. organic carbon, further disturbances may impact the landscape before the recovery from previous disturbance is complete. The resilience of the system can be maximised by adopting management practices that protect the natural resource base. It is, perhaps, fortunate that management practices that protect the resilience of the landscape also maximise the profitability of the farm business. This contention will be proven later.

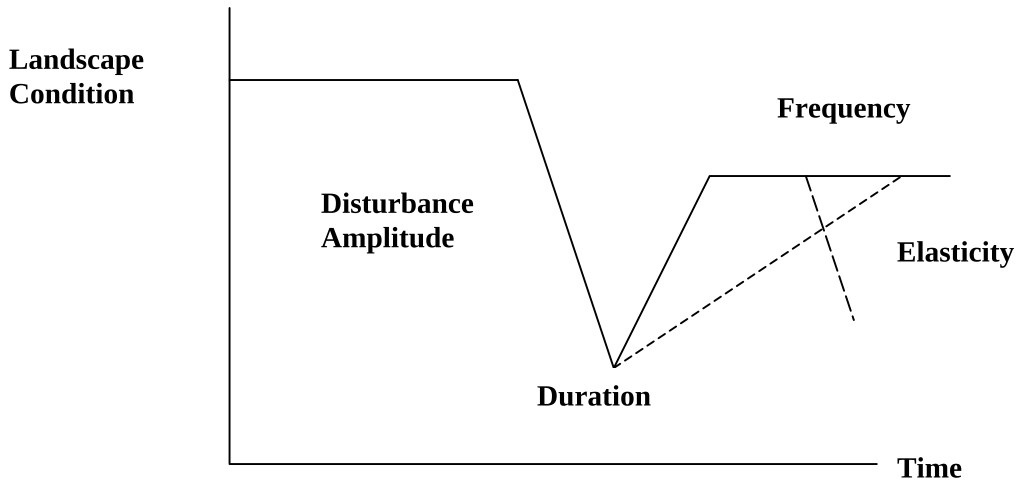


Diagram 6: Disturbance and Recovery at a Landscape Scale

Diagram 6 is taken from Hutchinson, 2005, and shows the concepts of disturbance and elasticity. The solid line shows what may happen in a drought situation when the landscape is utilised beyond its capacity. This causes quite a large disturbance. When the drought breaks, the landscape begins to recover. If well managed, this recovery may be of short duration and the landscape may return to its pre-drought condition. Evidence suggests that a new equilibrium will be established, with the landscape in worse condition than pre-drought. If the recovery is not well managed, it may take longer to return to equilibrium (dotted line). If the frequency of disturbances increases, one recovery may not be complete before the next disturbance occurs (dashed line relative to dotted line).

The history of agriculture in Australia identifies a number of cultural disturbance events. The influx of livestock to replace the herbivorous marsupials was the first major event and led to the loss of soil structure, changed water cycles and removal of groundcover producing a permanent change in species mix. The disturbances were exacerbated by the introduction and spread of pest animal species such as rabbits, goats and camels, and plants. Broad scale farming and land clearing followed as the capacity of the landscape to support low input grazing diminished. Upon these broad scale cultural changes, short term disturbances such as droughts have been superimposed. Climate change associated with global warming is predicted to increase the frequency of drought in Southern and Eastern Australia (Flannery, 2005). Given the low elasticity of our natural systems, management will need to focus on strategies that minimise the amplitude of drought induced disturbance. The alternative is a long term diminution of landscape productivity.

Australia’s fragile, relict soils and erratic rainfall makes recovery from disturbances slow and, often, incomplete. For example, in the arid rangelands of NSW, stocking rates have fallen from 1 DSE to 2ha to 1 DSE to 10ha between 1900 and the present, indicating an 80% loss of landscape productivity. Incursions of woody weeds and loss of valuable perennial grass species means that full recovery may not be possible. Similar examples can be found in long cropping rotations where grasslands take many years to recover after the cropping phase. This low resilience may encourage longer than optimal cropping phases because of low grazing returns for a number of years following disturbance.

The relationship between ecosystem change and fire frequency has been studied in depth. As fire frequency increases, ecosystem structure changes in favour of fire tolerant plants, which encourage more regular fires, shifting selection towards the more fire tolerant plants. Similar results may be noted in rangeland grazing situations, where pasture species have selected towards grasses of low grazing value or with short life cycles to ensure survival under grazing pressure during droughts.

Not all disturbances need be deleterious. The broad scale use of superphosphate and improved pastures during the 1950s and 1960s produced a positive disturbance. It is important for farmers to be aware that they can manufacture positive landscape changes that can redress previous negative events and increase resilience.

Secondly, the resilience of plant communities is highly correlated to their frequency in the landscape. Computer simulations show that, once frequency falls below 30%, many vegetation communities become terminal. Connectivity between areas of low and high plant density can improve the resilience of the low density area. Research shows that, at an evolutionary scale, sustainability requires large areas of remnant vegetation (much larger than can be contained within the National Parks system). Connectivity helps simulate large area processes.

Carrying Capacity and Stocking Rate

Philosophically, landscape resilience is determined by the difference between carrying capacity and stocking rate. Carrying capacity is a measure of the landscape’s ability to produce a sustainable and optimal volume of output. It is not constant and varies with variability in weather and climate. In the short term, seasonal rainfall and temperature fluctuations produce variability in carrying capacity. Many of the most productive natural systems are characterised by migratory activity, e.g. bison, caribou and wildebeest herds.

These systems are also characterised by population crashes resulting from short term variability in weather that impact on the capacity of the landscape to provide for existing numbers. Populations are kept within sustainable limits by available feed stocks.

Stocking rate is a measure of the amount of resource utilisation required to support the existing enterprises dependent on that landscape. As long as stocking rate is less than or equal to carrying capacity, landscape disturbance is minimised and resilience is maximised. In purely natural systems, an excess in stocking rate is managed by the death of the weakest individuals and reduced fertility amongst the rest. During periods of deficit stocking rate, numbers build up again. The closed nature of the systems means that the landscape will be in long term equilibrium, with stocking rate fluctuating within upper and lower limits. In natural systems, stocking rate will lag behind carrying capacity (resource use will exceed resource availability for some time before death rates increase) implying some degree of over-adjustment of populations.

Agricultural systems differ from natural systems in two important ways:

- They are open in that products are exported to areas distant from and unrelated to the point of production. Thus, factors that ensure long term balance in natural systems may not operate in agricultural systems, leading to disturbances of greater amplitude and longer duration, and slower recovery.

- Land managers have the capacity to make decisions and take actions to either reduce or increase the amplitude, frequency and duration of disturbances, e.g. cutting scrub to supplement stock feed availability in drought may increase the pressure on other plant species (grasses), producing outcomes that slow recovery after rain.

Careful and objective assessment of resource availability should allow farmers to respond to, or even anticipate, changes to carrying capacity and adjust enterprises accordingly.

Many production objectives are not met because current stocking rates regularly exceed carrying capacity for, at least, part of the production period. If this is the case, genetic improvement is unlikely to make any real difference. Management changes to reduce stocking rate, e.g. lower stock numbers or plant density, or increase carrying capacity, e.g. increase inputs of fertiliser or supplements, are more likely to be successful.

Plant Ecology and Physiology

Different plant species have different growth and reproductive cycles. Increasing the density of desirable species involves an understanding of the of the management practices that give them a competitive advantage relative to less desirable species. Strategic rest periods, removal of competitors and fertiliser applications can help speed up the process of desirable species dominance in pasture systems. Given the different ecology of different desirable plant species, it is highly unlikely that the same management will benefit all of them equally.

Plant physiology is mainly concerned with the processes that capture and utilise energy. An area of land has an energy potential equal to the amount of solar radiation that falls on it. Some of that energy is utilised in photosynthesis while the balance is lost. Photosynthesis is a relatively inefficient process, often capturing less than 10% of the available energy.

Management also impacts on the energy efficiency of the system. Plants deprived of essential nutrients have a reduced capacity to harvest radiant energy, as do plants with low green leaf area to intercept sunlight.

When the plant has harvested energy, it is partitioned within the plant to different end uses. Enzyme and hormone activity determine the partitioning. There are effectively four potential uses for captured energy:

- Extraction. This relates to the root system and its ability to extract sufficient water and nutrients from the soil.
- Conversion. Energy is captured by chlorophyll in the leaves and used to transform water, carbon dioxide and minerals into essential plant nutrients. Green leaf area influences this function.
- Reproduction. This is the fundamental purpose living things. In plants, it is usually triggered by daylight hours. Once this response has been triggered, it over-rides energy flow to roots and shoots. Eventually, the energy stored in the plant tissue will be translocated to the reproductive parts of the plant.
- Defence. Plants are designed to ensure reproduction. Some of the energy harnessed by plants goes to defence mechanism that help the plant survive. This includes such mechanisms as the production of toxins, conversion of sugars to complex carbohydrates (fibre) to make the plant less palatable and storage of energy in crowns to assist recovery from fire, grazing, etc.

The energy created by photosynthesis is transferred to the plant process that is most limiting energy capture. If the capacity of the plant to utilise energy is most limited by its capacity to extract water and nutrients, the products of photosynthesis will be transferred to the roots which will grow until they have sufficient extractive capacity to redress this limitation. Energy will then be redirected to the leaves to increase photosynthetic capacity.

Energy is transferred between extraction and conversion until maximum photosynthetic efficiency is achieved. Beyond this point, plants direct their surplus energy to defence and reproduction. Energy stored as complex carbohydrate enters the organic matrix as litter and is used by soil macro- and micro-organisms.

How does management affect energy conversion? If soils are deficient in essential plant nutrients, more energy is devoted to growing roots systems to increase the extractive capacity of the plant. Less energy is available for above ground biomass. Plant nutrient deficiencies in soils are the most common limiting factor to effective pasture production.

If plants are continuously grazed short (below 500kg of dry, green matter (DGM)), the restricted amount of energy that they capture is converted to photosynthetic area at the expense of their root systems. The pool of energy available for capture is reduced by both inefficient root and green leaf systems.

The total energy conserved as above ground biomass is available to fuel the livestock production system. Animals again partition energy between four key functions:

- Grazing. This is the energy required to move the animal across the landscape in search of its energy requirements. At low pasture production, animals use more energy just to obtain sufficient feed.
- Digestion. This is the energy require to break down the plant material consumed by the animal. As digestibility falls, more energy is required to break down the plant material. Methane production, a by-product of energy consumption, increases as digestibility falls.

- Reproduction. Energy is transferred from the female to the foetus. Low energy intake may be responsible for low birth weights.
- Defence. The animal protects itself against future pasture shortages by converting surplus consumed energy into fat, muscle and bone. This is available for future drawdown.

The grazier makes money from either reproduction or defence (weight gain). Pastures of low volume and quality waste energy in grazing and digestion, so cannot achieve optimal production levels. It is instructive to note that neither photosynthetic nor grazing efficiency can be achieved at pasture mass of less than 1,500kg DGM/ha.

There are some important principles that can be drawn from this analysis:

- A pasture mass of at least 1,500kg DGM/ha is necessary to maintain photosynthetic and grazing efficiency.
- Balanced soil nutrition is necessary to achieve optimal plant and animal production.
- Factors that increase evaporation, e.g. wind speed, temperature gradient and ground cover, reduce photosynthetic efficiency (and, by definition, animal performance).

Extreme Events

More than 90% of environmental degradation occurs as a result of extreme events. The most common extreme event in Australia is drought broken by flooding rain. How well we manage these events determines the amplitude and frequency of the disturbances associated with them. During a recent flood event in the Peel River (2003) at Tamworth, calculations based on river flow and sediment load readings indicated that 100 years of soil formation in the Peel catchment above Tamworth was lost in a three day period. At Greenthorpe in NSW, intensive storm rain on bare fallows led to soil losses of up to 700t/ha (about 2,000 years of new soil formation). One extreme event can undo many years of careful management. This is why many of the principles that determine appropriate land management relate to the achievement of minimum baseline standards.

Four Positives for Farm Managers

While the above prognosis may give the impression that farming in Australia is in a terminal condition, there are five reasons to be very positive about the future:

- Data from more than 2000 farms across northern NSW shows that, on average, 21% of rainfall ends up as production (grazing, cropping or litter) while 51% is lost to inefficiencies in the production system. Rainfall is rarely the most limiting factor of production in farming and grazing systems in Australia. Research undertaken in the Duri area near Tamworth (Gardiner and Browne, 2004a, unpublished) showed that average rainfall use efficiency (RUE) between farms varied from 18% to 28% but varied from 9% to 74% between paddocks on the same farm. In 2003-04, the average broad acre farm in NSW converted 73 mm of rainfall into production, based on ABARE farm size and production data. Rainfall utilisation ranged from 45 mm for specialist wool producers to 138 mm for specialist beef producers. When adjusted for available rainfall, rainfall use efficiency ranged from 15% for specialist wool producers to 19% for specialist croppers
- The above data plus many examples from yield monitoring experiments indicate that there are parts of many properties that are not covering the variable costs of production (negative gross margin). It is more profitable to not attempt production on these areas in the short term. A farmer in the Duri district, near Tamworth, stopped production on 120 ha of 440 ha and increased profit by $7,000. Most

farmers have insufficient data to establish where these areas are located on their farms

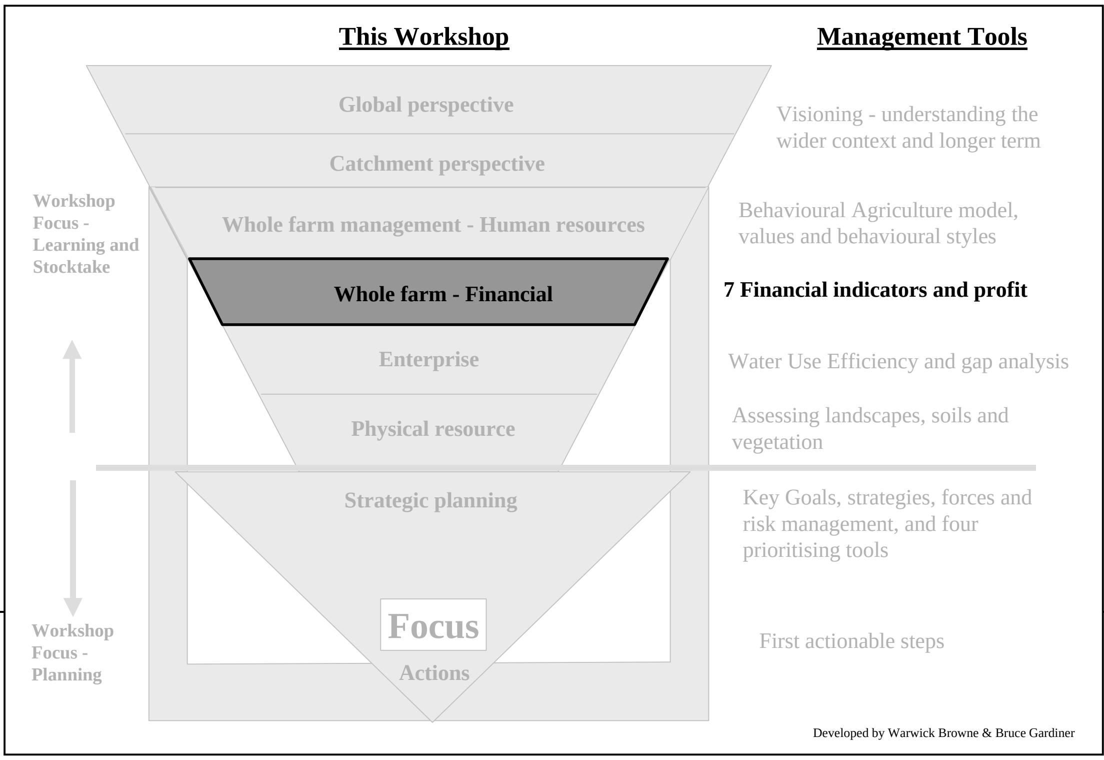
- Profit is generated in about equal proportions from production, management and marketing. Most farmers do not have robust monitoring systems for assessing management decisions nor are they generally adept at marketing. Most farms are therefore operating at about one third of their profit potential.
- Most farmers are unable to separate the concepts of profit, income and production, commonly using the three terms interchangeably. Even when the difference in these concepts is recognised, they are still thought to move in the same direction, that is, more production equals more income equals more profit. Thus, most farm management decisions are more concerned with maximising production than profit. Farmers lack the robust monitoring systems that would allow them to make rational production decisions. Unless demand is price elastic and all inputs are ‘free’, these three outcomes are **always** maximised sequentially, profit first, then income, then production.
- A close analysis of the available data shows that farmers have the capacity to control the outcome of their farm business. If, as has been shown above, rainfall is never the most limiting factor of production, then the corollary is that farmers have complete control over all other inputs and input combinations.

Because the above four points are generally not recognised as true, assumptions about rainfall, farm efficiency and profitability combine to restrict the options available to farm managers to improve the personal, financial and environmental performance of their farms.

On the next page you will begin your Farm Business Strategic Plan by formulating your vision for what you would like the farm to be like in the future.

Financial resources – Whole farm

Diagram 11 This Workshop



Most farmers accept that lack of money is the biggest single issue that they have to deal with. At the same time, evidence from the local rural financial counselling service suggests that the first indicator that the farm is in financial trouble is the bank bouncing a cheque. At this stage, it is too late to do anything by about 5 years.

If financial performance is so important to long term survival (and natural resource management), why do farmers know so little about it?

Following are some of the reasons:

- Behavioural style – the physical nature of farm work attracts those who are not good at bookwork (75% of the general population probably find reporting less than fun).
- Literacy and numeracy skills of farmers are not high. Complex lists and tables cause number lock-up, resulting in farmers just reading the bottom line.
- The principle sources of financial data are bank statements and tax accounts. Neither provides good farm management information.
- There is a pre-occupation with tax minimisation rather than profit maximisation.
- The use of nominal, rather than real, data hides important long term trends.
- Off farm income, depreciation and capital gain subsidise (and hence corrupt) farm business performance.
- They try to distance themselves from the problem. So long as there are subsidies, greenies, banks, governments, not enough rain, too much rain, supermarkets, etc, there is no need to challenge own farm management.

Taxation vs Management Accounting

Good farm financial management data must have two characteristics.

- It must be consistent i.e. measure the appropriate variables and
- It must be comparable through time i.e. trends are more important than absolute values.

Taxation accounting allows the values of opening and closing stocks in livestock and produce trading accounts to be varied to minimise trading profit (tax liability). Because this data is flawed, decisions based on it are also flawed. The income from an enterprise (trading profit) is the value of total sales minus total purchases. This is the money that the farmer has to operate the farm business. Whether this income was generated by running down stocks is an entirely different management issue.

Depreciation is included as a cost against the business even though farmers don't pay it and don't necessarily replace items when they are depreciated to $0. Farm cash income can be supplemented by depreciation eg if a farmer's depreciation costs fall from $50 000 to $0, he has effectively made $50 000. The purpose for tax deductibility of depreciation is to keep capital in as new condition.

Debt, financed through capital gain on farm assets, can be used to supplement income.

Where is all this leading? Effectively, the farmer runs many different businesses within the overall farm business. He runs a real estate business based on land, an employment business with his labour, a contracting business with machinery and infrastructure and a farming business with each of his enterprises. Unless each of these are separated out and assessed independently, there is a strong chance of cross subsidisation and inaccuracies in enterprise evaluation.

Comparing Data

Trends in data are more important than absolute values. To draw meaningful information from trends, data must be manipulated in some way to ensure comparability through time (temporal consistency) and to account for changes in the size of the farm as a business (spatial consistency). It is noted that it is extremely difficult to draw a trend from one or two observations, although it has been done in the past. The longer the data series, the more meaningful will be the result.

There are two methods of ensuring temporal consistency. The first is to use real data i.e. deflate the money value of income and costs by some widely accepted deflator e.g. CPI. The second is to use ratios or percentages e.g. the ratio of farm debt to cash income. Because debt and income at any point in time are measured in the same dollars, the ratios so calculated are independent of time.

Any problems of spatial inconsistency can be dealt with by assessing data on a per unit of production basis e.g. per hectare, per labour unit, etc.

Long term data for Australian agriculture indicates that total farm profitability (real net value of production) has declined by a trend value of 67% since 1960 but, because of an almost equal decline (50%) in the number of farmers, profitability per farm has only declined by one third, thus the need for spatial consistency.

Because it is highly unlikely that 1 or 2 really big operations going broke has skewed the data, it would appear that most farm businesses are becoming less profitable. Similarly, real long term data on farm costs and incomes show that costs are increasing at least six times faster than income, i.e. every extra dollar that farmers have made since 1960 has cost more than six dollars to make. Again, it is highly unlikely that one or two producers have skewed this data, implying that this pattern is consistent across most farms. Unless these trends are addressed, there will eventually be no farmers. Until they are recognised by individual farmers, nothing will change.

Financial Performance Indicators

The purpose of this section is to develop and calculate a small number of robust indicators of farm financial performance. The first part of this analysis is to assess the capacity of **all** the different businesses undertaken on the farm to generate and expend cash. The second assesses the capacity of the farm enterprises to generate and expend cash. We are principally interested in cash flows at this stage. Decisions about how income is generated this year will affect cash flow (and trends) in following years. Stocks cannot be run down for ever. At this stage we are only interested in whole farm performance. Methods for analysing different enterprises will be discussed later.

Because the most commonly available source of financial data for most farmers is their tax accounts, the following analysis is based on modifying this data so that it is useful for making management decisions. It is based on modifications to Farmpack to ensure all accounting is on a cash basis.

There are eight indicators that can be used to assess which areas of financial management need to be addressed to avert future problems. We concentrate on indicator four.

Trends of these indicators over time give a better picture of whole farm business health than just one year's results.

Stock Trading and Depreciation are likely to be the main difference between Tax Accounting and Management Accounting. FarmPack adjusts Tax records to give real management figures.

These indicators, below, measure Cash Flow (1,2,3,4), Equity (5), and Profit (6,7,8). In brackets are the suggested targets for a healthy farm business.

1. Liabilities to income $\dfrac{\text{Total liabilities}}{\text{Total Farm Cash Income}}$ **(<1.5)**

2. Business costs to business Income $\dfrac{\text{Total farm business costs}}{\text{Total farm business income}} \times \dfrac{100}{1}$ **(55 to 65%)**

3. Farm finance costs to business income $\dfrac{\text{Total finance costs}}{\text{Total farm business income}} \times \dfrac{100}{1}$ **(<15%)**

4. (Not in FarmPack) 2+3 should probably be less than 80%

5. Equity $\frac{\text{Net Worth}}{\text{Total assets}} \times \frac{100}{1}$ **(>65%)**

6. Return to capital $\frac{\text{Operating profit}}{\text{Total Assets}} \times \frac{100}{1}$ **(>0%)**

7. Return to equity $\frac{\text{Business return}}{\text{Net worth}} \times \frac{100}{1}$ **(>0%)**

8. (Not in FarmPack) Marginal Revenue (MR) – Marginal Cost (MC) = 0

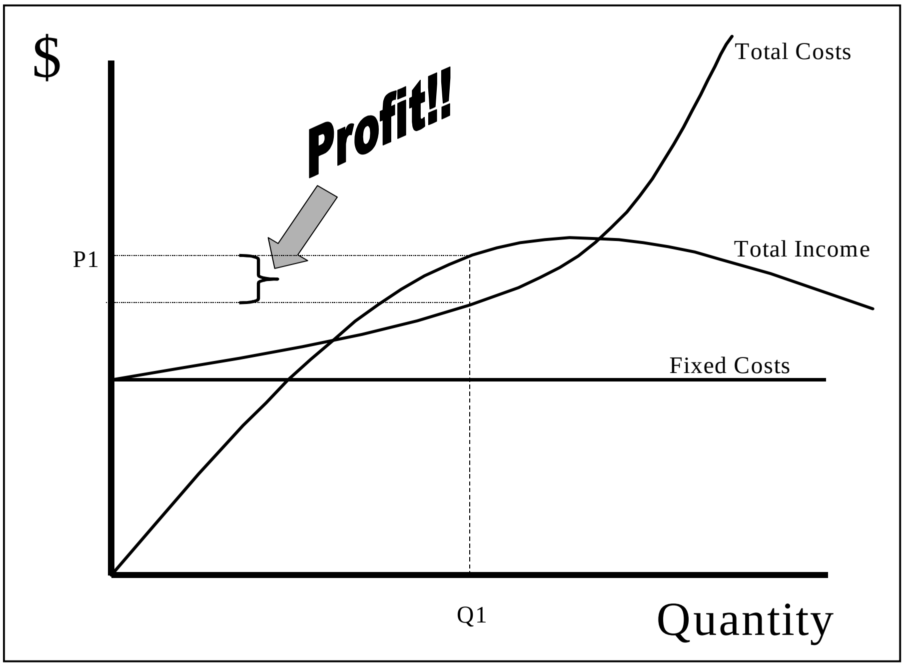
$$MR = \frac{\text{Total Revenue this year}}{\text{CPI this year}} - \frac{\text{Total Revenue last year}}{\text{CPI last year}}$$

$$MC = \frac{\text{Total Cost this year}}{\text{CPI this year}} - \frac{\text{Total Cost last year}}{\text{CPI last year}}$$

Profit

There is evidence to strongly suggest that most farm businesses are operating at a level of production which is greater than the second break-even point below. At this point Total Costs are higher than Total Income and strategies such as increasing debt and running down capital are commonly used to keep the farm business in business. These strategies are not sustainable in the long term.

Diagram 12. Profit



Let us consider some of the philosophy underpinning Diagram 12. Before agricultural production can commence, the farmer must first obtain the necessary land, capital and infrastructure. The cost of obtaining these are the fixed costs necessary to get production started and are constant in the short term and over the possible area of production. In the long term, all costs are variable.

Once the production process commences, variable costs must be added to fixed costs to get the total cost of production. Variable costs increase at an increasing rate because of diminishing marginal product i.e. as the system approaches it productive limit, it takes increasing amounts of input to get an additional unit of output.

Product is sold to produce total income. Provided price per unit is higher than variable costs, the total income line will eventually intersect with the total cost line. This is the breakeven level of production. The law of diminishing marginal returns ensures that marginal revenue (and, eventually, total revenue) declines with increasing production. The total income and total cost curves will eventually intersect again. Profit can only be earned between these two points of intersection and is maximised when the slopes of the total income and total cost curves are the same i.e. when marginal revenue equals marginal cost. If the two curves do not intersect, this solution will minimise losses.

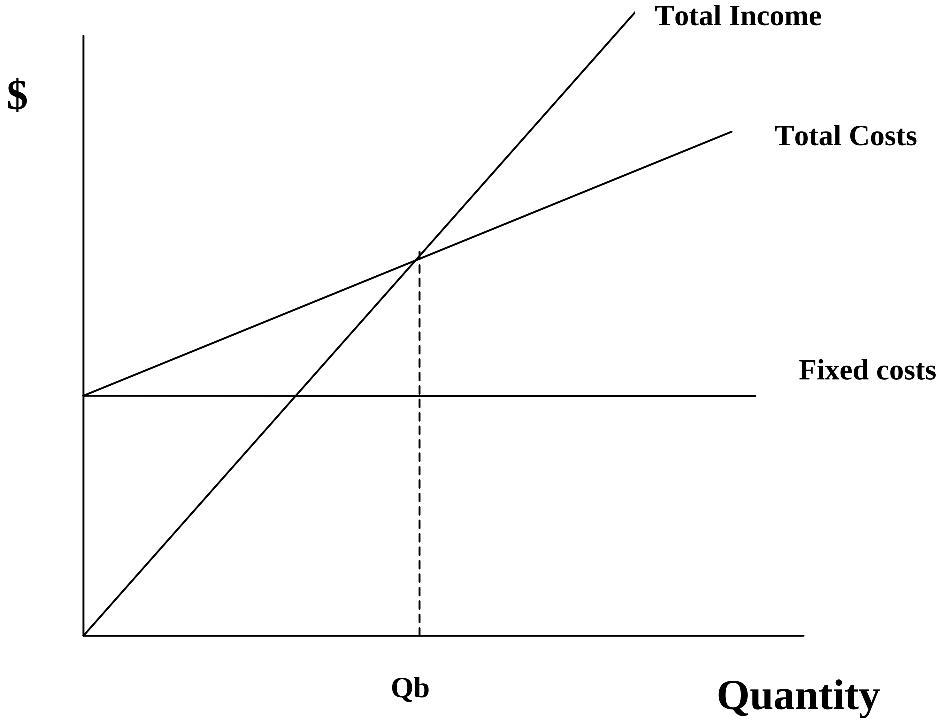


Figure 13: Alternative model for Assessing Farm Level Profit

Figure 13 demonstrates a commonly used formulation of the total cost/total income/profit model used in Figure 12. Its appeal relates to its capacity to demonstrate that increasing production generates additional profit. However, it also implies certain economic and production conditions that cannot be justified, theoretically or empirically. These include:

- A linear production function. The linearity of total costs and income implies that a constant volume of output is produced from a constant volume of inputs. This implies constant marginal returns rather than diminishing marginal returns to inputs. Diminishing marginal returns is a pillar of the economic theory of production and has been demonstrated in numerous experiments in agriculture (see Heady,

1952) It also implies that it is impossible to maximise production because MP must always be positive. An obviously unintended consequence of this is that it is possible to feed the world from a flowerpot if inputs can be poured into it, and the production can be harvested from it, fast enough.

- Constant MR and MC. If the slope of the total income curve is greater than the slope of the total cost curve, MR will always be greater than MC and profit can never be maximised. MR and MC will be horizontal lines. This also implies that both the demand curve and supply curve are horizontal lines that can never intersect, implying that market equilibrium can never be achieved.
- Supply and demand curves are perfectly elastic.. Declining real prices and increasing real costs in the face of increasing production are sufficient to demonstrate that this is not the case in either the short or long term.

The scenario presented in Figure 12 demonstrates that MP is continuously diminishing and can become negative, implying production can be maximised, and marginal costs increase as production approaches a maximum. MR (MPxPo) declines as MP declines, implying a negatively sloped demand curve and, at least, the possibility of being able to maximise income and profit. The total cost and total income scenarios are consistent with diminishing marginal returns and shows that total costs can increase as production falls if that fall is due to the utilisation of inputs beyond the point that maximises production.

What is the link between profitability and production? How can financial data be used to help determine optimal levels of production? On my farm, will more production lead to more profit? The relationship between production and profit can be stated as an axiom. Production should increase so long as the additional **real** income earned from that extra production is greater than the additional real cost of producing it. We can show this relationship diagrammatically.

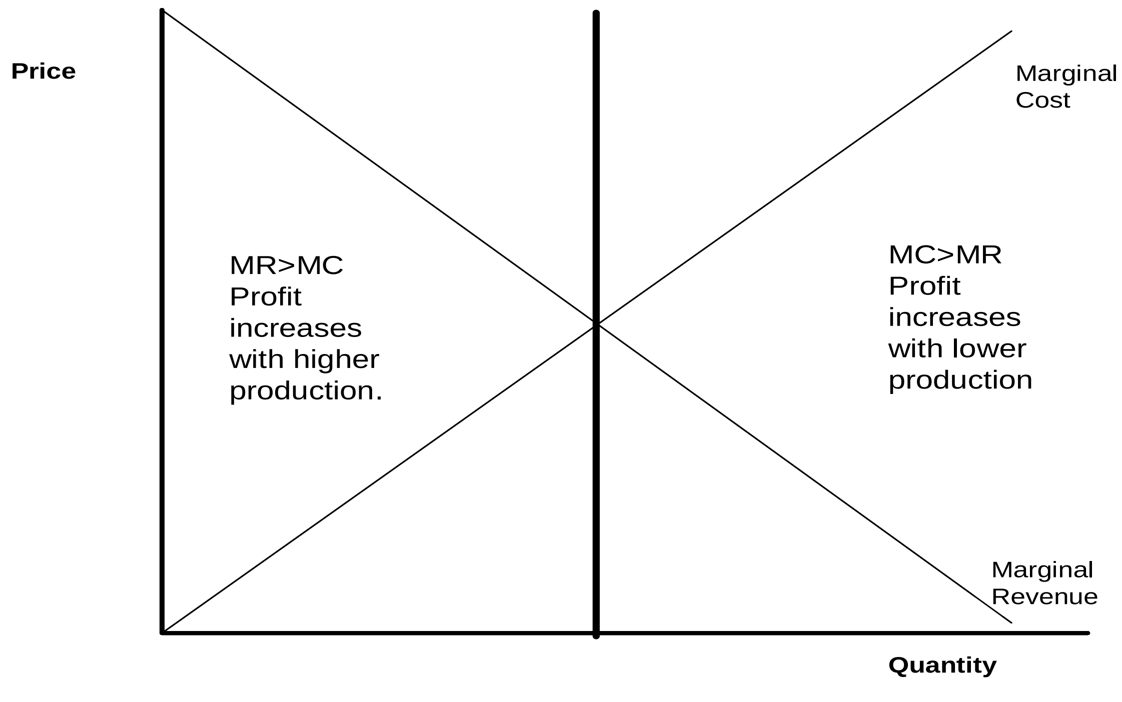


Diagram 14 Relationship between Production and Profit

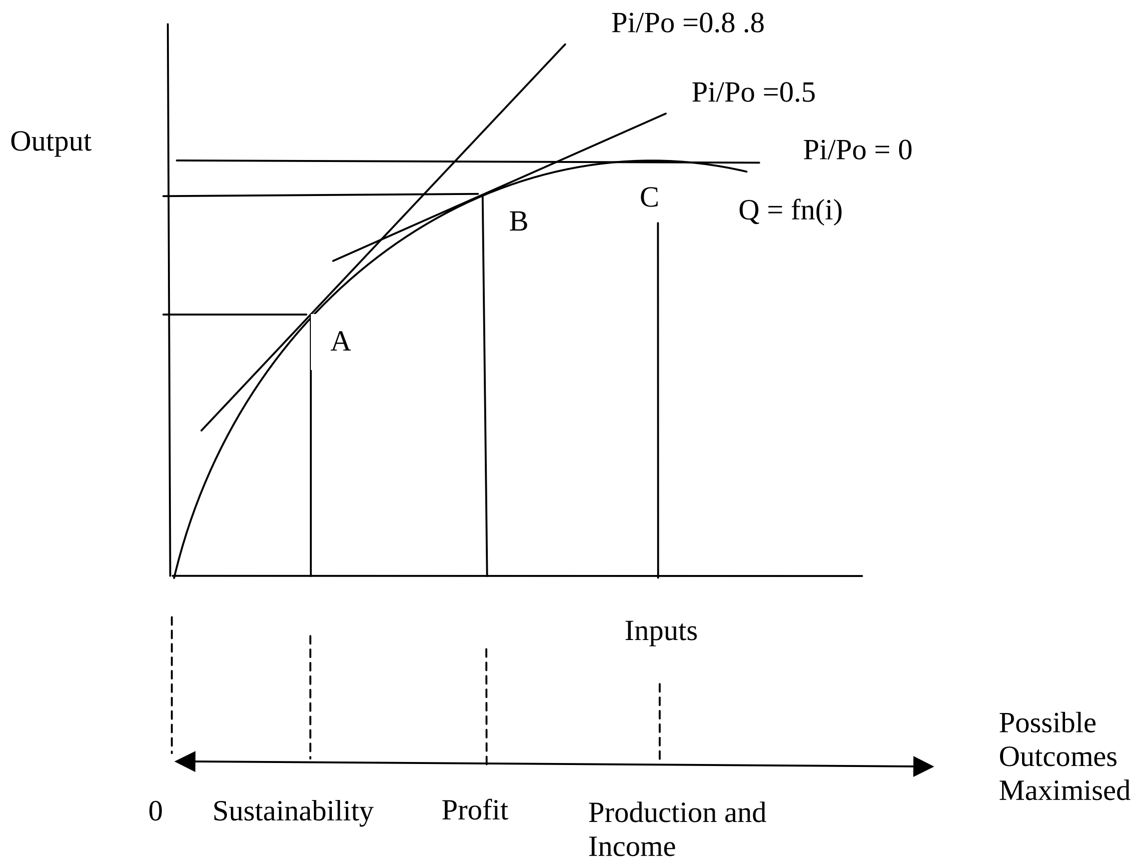


Figure 2: Production functions, price ratios and production decisions

Figure 2 demonstrates the same principles as Diagram 13, only from the production perspective. Note that, at any point to the right of a point of tangency in Figure 2, MR (MP*Po) is less than MC (Pi). The opposite applies for any point to the left. The ratio of total costs to total income from a farmer's tax accounts provides an approximation of the Pi/Po ratio. This ratio may be rising, falling or constant.

If the ratio is constant, costs and income are moving in the same direction at the same rate (MR = MC) and profit is being maximised under existing management. From Figure 2, Q = fn(i) represents all possible combinations of inputs and outputs given existing management. If Pi/Po (ratio of costs to income) is constant at 0.5, then the farmer is maximising his profit at point B on his production function. If the ratio of costs to income changes to 0.8, the volume of inputs and outputs need to change (fall) to point A to maximise profit. It is easy to see that continuing to produce at point B will no longer maximise profit given the change in prices ratio.

If the ratio is rising, there are two possible explanations:

- Costs are rising faster than income. From Diagram 14, this is equivalent to being to the right of the point of intersection of the MR and MC curves and continuing to increase production. The equivalent process from Figure 2 is to be expanding production from A to B while the price ratio is 0.8.
- Income is falling faster than costs. From Diagram 14, this would imply that the producer was operating in the area to the left of the point of intersection and reducing production. The equivalent from Figure 2 would see the producer moving from points B to A while the price ratio was 0.5.

The trick is then to work out which option is actually happening. This can be easily identified by assessing year on year change in real total costs. If the ratio is rising because costs are rising faster than income, the year on year change in total costs will be positive and current production will be to the right of optimal and increasing. To be precise, the change in real costs (costs adjusted by the CPI) should be calculated but using nominal values is better than doing nothing. Profit may be increased by reducing production. If the ratio is rising because income is falling faster than costs, the situation will be to the left of optimal, the year on year change in total costs will be negative and profit may be increased by increasing production.

If the ratio of costs to income is falling, there are two possible explanations:

- Income is rising faster than costs. From Diagram 13, this is equivalent to being to the left of the point of intersection of the MR and MC curves with production increasing. The equivalent from Figure 2 is to be increasing production from A to B with a price ratio of 0.5.
- Costs are falling faster than income. From Diagram 13, this would imply that the producer was operating in the area to the right of the point of intersection and reducing production. The equivalent from Figure 2 would see a producer moving from B to A with a price ratio of 0.8.

Again, the trick is to know which alternative is the appropriate one. If the ratio is falling because costs are falling faster than income, the year on year change in total costs will be negative, the producer will be operating in the region to the right of optimal and reducing production and profit may be increased by a further reduction in production. If the ratio is falling because income is rising faster than costs, the situation will be to the left of optimal, the year on year change in total costs will be positive and profit may be further increased by increasing production.

Trends in the cost to income ratio can be misleading if expenditure on essential inputs is reduced to cover shortfalls in income, e.g. fertiliser application is often foregone in low income years, even though this may be at the expense of long term sustainability. Farmers are requested to pay particular attention to the "Cautionary Note" on page 64. It is not difficult to fudge the data but the only person you are kidding is yourself.

The important principles to remember are that trends can only be up, down or sideways and the change in real total costs can be either positive, negative or zero.

Given the above analysis, there are nine management implications that can be drawn from the data, depending on whether the cost to income trend is constant, rising or falling and year on year change in total cost is zero, negative or positive. These implications are presented in the table below.

Result Matrix

Marginal Cost (D)

Graph trend (trend in cost to income ratio)		0	negative	positive
	Flat	Implies optimal production	Implies costs and income are falling proportionally. Implies optimal production.	Implies costs and income are rising proportionally. Implies optimal production.
	Rising	Implies income is falling. Check prices and natural resource condition (may be declining). Optimal decision may be to reduce production.	Implies business is producing less and moving away from optimal B to A with ratio of 0.5 in Figure 2	Implies business is producing more and moving away from optimal A to B with ratio of 0.8 in Figure 2
	Falling	Implies income is rising. Check prices and natural resource condition (may be improving). Optimal decision may be to increase production.	Implies business is producing less and moving toward optimal B to A with a ratio of 0.8 in Figure 2	Implies business is producing more and moving toward optimal A to B with a ratio of 0.5 in Figure 2

Use the following worksheet to calculate the trend in the costs to income ratio and the change in year on year (MC) costs. It may be instructive to note that, for the past 40 years for Australian agriculture as a whole, the costs to income ratio has been rising and real total costs have been increasing. What is the implication of this from the above matrix of results?

Page for calculations.

Whole Farm Financial Analysis

Inferring Production Implications from Financial Data

A	Total Costs from Tax Accounts							
B	Total Income from Tax Accounts							
C	A / B (cost to income ratio)							
	Graph of C.							
D	Real Total Costs this year minus Real Total Costs last year (Marginal Cost)							
	Result							
	Year							

Changes in technology and management practices will change the cost to income ratio and the optimal (profit maximising) level of production.

As long as the price received for an additional unit of production is higher than the cost of producing it, marginal revenue will be higher than marginal cost and profit can be increased (loss reduced) by producing more. Conversely, if the additional income from increased production is less than the additional cost (MC>MR), profitability can be improved by decreasing production. Similarly, the effectiveness of management change can be measured against its impact on the costs to income ratio and the total cost of production.

A Cautionary Note

There are imperfections in taxation accounts data in both the income and costs calculations. This is probably not an issue for calculating long term trends but may throw up some interesting figures on a year to year basis. For consistency, it is desirable to use total farm cash income and costs from Farmpack.

The cost to income ratio identifies whether economic profit is being maximised. This ratio will only determine whether the existing management is sustainable if **all** costs are accounted for. Particular attention should be paid to the following:

- Natural resource rundown. Are all nutrients being removed from the property in the form of production being replaced? Is groundcover always high enough to ensure that soil loss and formation rates are approximately equal? If not, are the additional nutrients lost to erosion being replaced? Is soil organic carbon being maintained? Are there any visible signs of other land degradation indicators e.g. weeds, salinity, dieback, etc.?
- Debt levels and principal repayments. The availability of interest only loans can be masking the relative importance of capital gain and production as a driver of the farm business. Farm debt has increased from $28bn to $50bn during the 6 years to 2005-06.
- Operator’s allowance. Is the farm business paying a reasonable return to the labour and management components of the business? Is off-farm income being used to support the farm business?
- Depreciation. Is capital and infrastructure replaced as its depreciated value becomes zero or does depreciation support other farm costs? The tax deductibility of depreciation is designed to maintain plant and infrastructure in as new condition.
- Off-farm impacts of farm business operation. Some examples include chemical resistance, chemical contamination, greenhouse gas production, declining water quality, sedimentation of streams and species extinction. These impacts are otherwise called externalities.

A Banking Analogy

All of the above, if not explicitly addressed, lower the cost to income ratio and lead to a level of production that is higher than that which is sustainable. It is possible to put values on most of these and adjust total costs accordingly. Once all of these have been calculated, the Pi/Po ratio will give the maximum sustainable yield.

Increasing Profit

There are three basic ways to increase profit.

1. Lower fixed costs - labour efficiency, syndication, lease land

2. Increase Gross Margin - See falling cost to income ratio above.

3. Change Throughput - production should be varied until MP = Pi/Po. This may require a reduction in output.

The data from indicator 4 above can also be used to measure changes in real profitability. If the ratio of business plus finance costs to business income is rising, costs are rising faster than income (or income is falling faster than costs) and real profit is falling. If the ratio is falling, income is rising faster than costs (or costs are falling faster than income) and real profit is rising. If the ratio is constant, costs and income are changing proportionately and profit is maximised under the current management system.

Any change in farm management can be assessed against its capacity to impact on fixed costs and/or gross margin. As stated above, increasing throughput is only an option if the existing level of production is less than that which maximises profit. Data from the cropping sector shows that profitability has declined in the face of increasing production. This again may be due to a few producers skewing the result for everybody else but that is highly unlikely. It is far more likely that profit decline is an industry wide phenomenon. Declining profit in the face of increasing output is symptomatic of overproduction.

Financial Assessment of Management Change

As a rule of thumb, decisions that lead to lower fixed costs also lead to higher variable costs e.g. leasing land negates the fixed cost of owning land but the per hectare lease payment must be added to variable costs. By definition, there must be a level of production for which leasing land is better than owning it. Similarly, it may be profitable to trade high value, more fertile land for lower value, less fertile land with higher input costs.

The same analysis can be used for plant and machinery. Is it better to buy, lease or contract? Leasing or contracting lowers the fixed cost by the purchase price of the machine but increases the variable costs. Because leasing is time based and contracting is area based, there will be some level of production for which contracting is more profitable than leasing. The variable cost of operating owned machinery is lower than that for leasing or contracting so there will be some point at which owning becomes the most profitable option.

Improvements in gross margins are achieved by technologies and practices that increase productivity. In a macro sense, this is only true if the same level of production is achieved with fewer inputs. Once technology is used to increase production, other factors come into play and the financial outcome cannot be stated with certainty. If overproduction is already the problem, it is unlikely that more production will be the solution. It must be remembered that total income is price sensitive and price is production sensitive. Productivity gains may be achieved through low (management change) or high (increased inputs) cost methods.

The other alternative is to use the same inputs to produce a higher priced output. This can be achieved by improving the quality of the product in existing markets or selling the existing product into a higher price market.

Weeds, pests and diseases increase variable costs in their management and may reduce the price received for the grain through contamination or quality reduction. Where these problems exist, the optimal level of production is lower than in clean conditions.

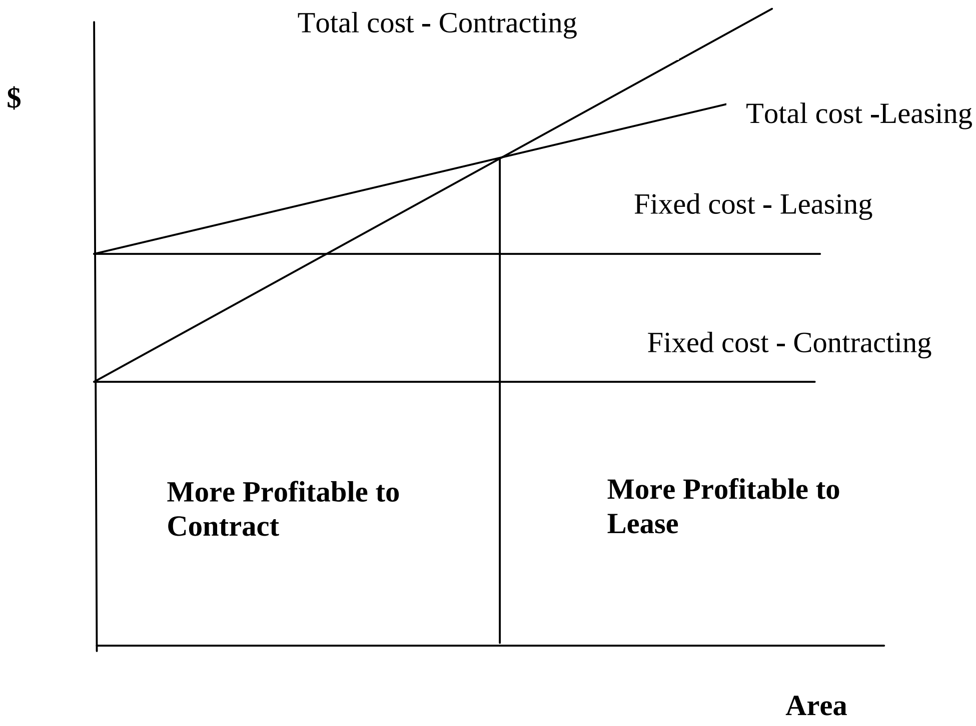


Diagram 14   Determining optimal management decisions for alternative machinery options

These are some examples of how the above analysis can be used to assess the likely profitability of management changes. Diagram 14 shows the difference in cost structure between leasing a machine and doing the job yourself or contracting somebody else to do the job for you. Leasing the machine adds to fixed costs by the annual lease payment. Contracting adds to variable costs because the contractor has to meet all the costs of ownership plus make a profit.

The farmer saves the cost of the machine but pays for the privilege of having someone else do the job. The total cost curve rises more rapidly for the contracting option and cuts the total cost curve for the leasing option at some point. At any level of production below this point of intersection (Q1 in Diagram 14), it is more cost effective to contract the job. For levels of production greater than Q1 leasing the machine is the better option. Here is an example for a harvester. It costs $50 000 per year to lease the machine but only $25 per hectare to operate it. Under the same set of operating conditions, it would cost $50 per hectare to contract harvest the crop. What is the break even area of crop required to justify leasing the machine? The answer is given by dividing the lease payment ($50 000) by the difference between the contract cost per hectare and the owner operator cost per hectare ($50 - $25 = $25). $50 000 divided by $25 equals 2 000 hectares. For areas less than 2 000 hectares, contracting is the most profitable option.

Financial Summary

Work through FARMPACK yourself or get your accountant to do it for you and enter the results in the table below. Do this for the past 5 years if possible. Trends are extremely important.

Year

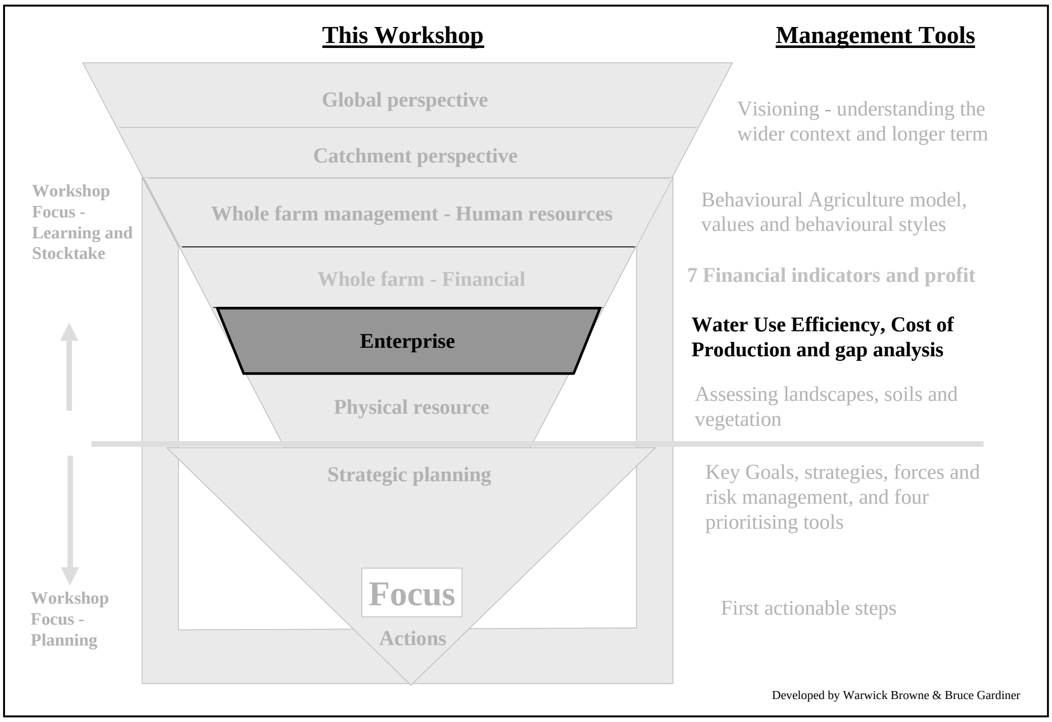
Liabilities to income					
Business costs to business income					
Farm finance costs to business income					
Indicator 2 + Indicator 3					
Equity					
Return to capital					
Return to equity					
MR - MC					

Your comments:

Key Goals (from this data, write down 1 or 2 key goals necessary to your vision). These should be Specific, Measurable, Realistic and Time constrained (when will it happen by).

Enterprise Evaluation

Diagram 15 This Workshop



Introduction

The profit you make or don't make in a Whole Farm Financial sense is reliant on the performance of the separate enterprises. Cost of Production (COP) and Gap Analysis can be used to measure this performance and identify potential areas of profitable change. It is important to consider **all** of the costs associated with producing a product. Failing to do so lowers the cost of production, lowers marginal cost and may lead to a decision to produce more when this is not justifiable. There are many non-cash costs that should be considered e.g. farmers labour, soil decline, greenhouse, etc.

Unit COP = Variable Costs + Share of Fixed Costs + Share of Labour Costs + Share of Finance Costs / Quantity

(The units of COP may be cents/kg, $/head, $/tonne for example.)

Gap Analysis

Total revenue is calculated by;Total Revenue (TR) = Price (P) x Quantity (Q)

Price is a function of quality, and quantity is a function of production efficiency. Perform a Gap Analysis on all enterprises. Rainfall Use Efficiency will be used to further evaluate production efficiency.

Total Revenue – Price Gap Analysis

The price received for a product is a function of a number of quality factors. The following table allows you to perform a Gap Analysis which is an assessment of the value of improving these factors. It is important to specify the product accurately as there may be different quality factors for the same product into different markets eg feed or malting barley.

Quality Factor	Measure	Target	Current	Gap	Value
Eg grain protein	%	13	12	1	$15/ha

Fill out a separate gap analysis for all of your enterprises.

Addressing which factors in which enterprises will give the best return??

Total Revenue – Quantity Gap Analysis

What are you producing? What are the factors which affect how much you produce? (eg. kg/ha, weaning rate)

Quantity Factor	Measure	Target	Current	Gap	Value
Eg yield	t/ha	3	2	1	$300/ha

Addressing which factors in which enterprises will give the best return??

Fill out separate gap analysis for each enterprise.

See rainfall use efficiency below to help you assess what quantities are possible.

Production Functions, Profitability and Natural Resource Management

There is something intrinsically appealing about the concept of good natural resource management improving farm profitability. While much research has been undertaken which proves that certain elements of NRM improve farm profits, there is no general theory that explains why this should be so. The following is presented as proof that farmers cannot maximise their profit if they are not optimising farm NRM. A number of natural resource indicators, though by no means all inclusive, are presented as measures of potential farm profitability. If achieved, farm sustainability would also be enhanced.

The Economics of Production and Natural Resource Use

The microeconomic theory of the firm with regard to production is based on three important concepts:

- The producer wishes to maximise profits.
- To maximise profit, each input should be used to the point where the value of its marginal product (MPa*Po or MVPa) equals its cost (Pa) or MVPa/Pa = MVPb/Pb = …………. = MVPn/Pn = 1 for all n inputs. This determines optimal output volume.
- Input mix should be varied until the ratios of their marginal products equal their price ratios, i.e. MPa/MPb = Pa/Pb or MPa/Pa = MPb/Pb = …….. = MPn/Pn for all n inputs into a production process. MPa/MPb is also known as the rate of technical substitution (RTS) and measures the amount of one input (a) that can be substituted for another input (b) and leave total quantity of production unchanged. This measures relative input intensity.

The reader may confirm the veracity of this by reference to any micro-economics text. My source is J M Henderson and R E Quandt, Micro-economic Theory: A Mathematical Approach, Second Edition, McGraw Hill/Kogakusha, 1971, pp53-100. The purpose of this analysis is to show the linkages between farm natural resource management and profitability and the proof that profit cannot be maximised in the absence of sustainable natural resource management.

For the purposes of this analysis, we will consider the two input case. The two inputs are defined as purchased and free. The only input that is free to farmers is the weather. Weather is defined as rainfall, solar energy and wind run and its net effect can be measured as rainfall use efficiency (RUE) or the amount of rainfall that is utilised, in situ, for production of plant material. The components of RUE are crop production, livestock production, litter and positive or negative change in plant mass

.

Because the weather is effectively free, it should be utilised up to the point where its marginal product is zero or production from the available weather is maximised (condition three above. If Pi = 0 then MP must also equal zero). For any level of production, the weather should be substituted for purchased inputs to the point where the rate of technical substitution between the weather and purchased inputs is zero, i.e. where purchased inputs for that level of production are minimised and utilisation of the weather is maximised (condition two above. By definition, Pweather = 0. Therefore, MPweather/MPother inputs must also equal zero which can only happen if MPweather equals zero. The alternative is for the MP of other inputs to be infinite).

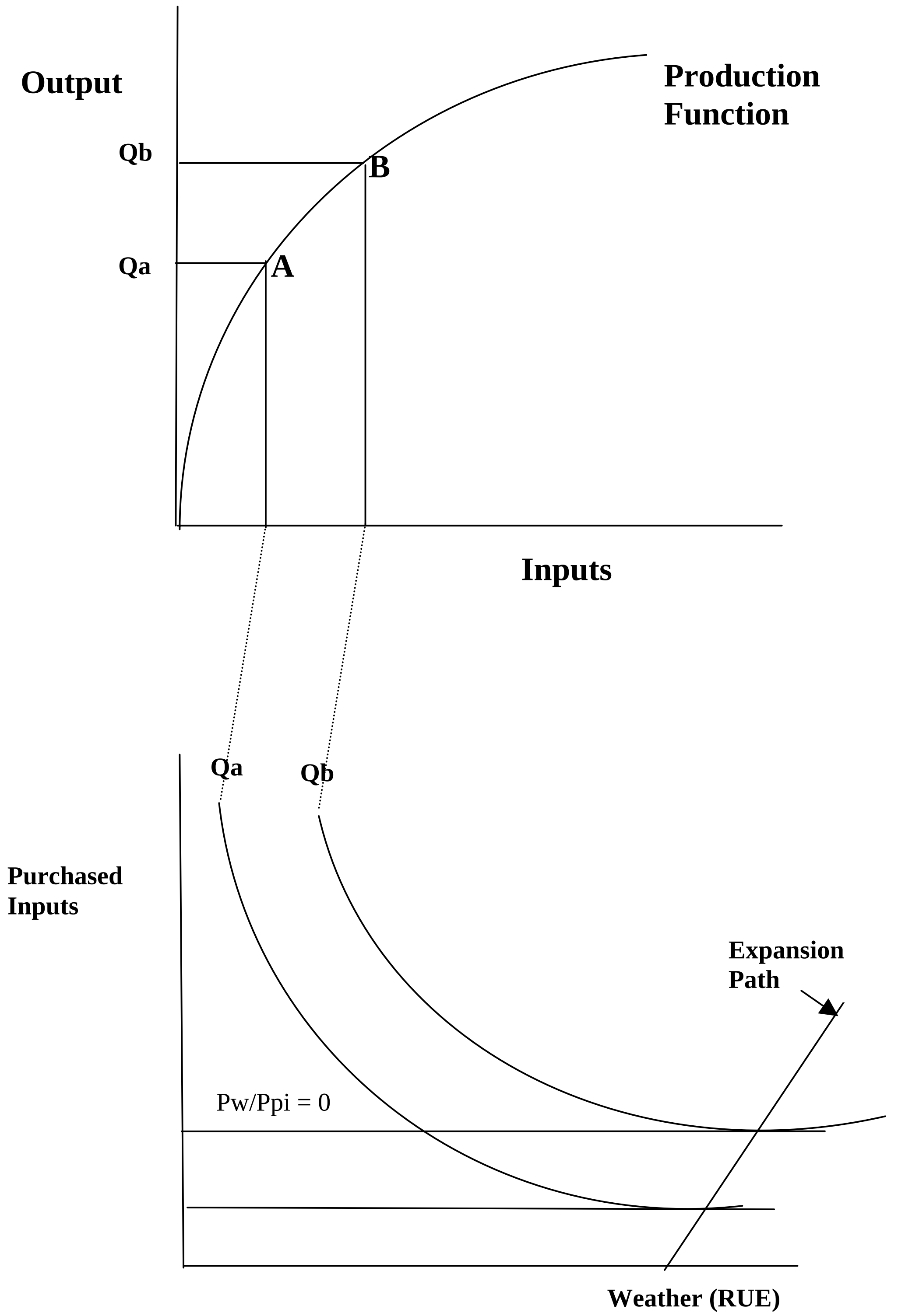


Figure1 The Relationships Between a Production Function and Associated Isoquant and Isocost Map.

This relationship is shown diagrammatically in Figure 1. The production function shows all the different input-output combinations that are possible with existing farm management. For the purposes of this exercise, we shall consider two points on that production function, A and B which give outputs of Qa and Qb, respectively. These two outcomes can be plotted onto an isoquant map. Isoquants represent all the possible combinations of inputs that could achieve a given amount of output. From this map in Figure 1, it can be seen that it is possible to utilise different combinations of weather and purchased inputs to achieve the same amount of output.

At one end of the spectrum, a given amount of production could be achieved by utilising most of the available weather and few purchased inputs or by using more purchased inputs (e.g. feed supplements) and less efficient use of the weather. The most appropriate mix of inputs is determined by tangency between an isoquant (RTS) and the price ratio of the inputs. This line is called an isocost curve, or budget constraint. It measures all possible combinations of inputs that could be purchased with a given budget. In this case, where inputs are defined as either free or purchased, profit is always maximised when the utilisation of the free input is maximised (Pw/Ppi = RTS = 0). The most appropriate level of purchased inputs is that which allows maximum rainfall use efficiency (RUE) to be achieved for any level of production (RUE has been postulated as an appropriate surrogate for weather. This will be expanded later.)

The expansion path for the farm business is defined by these tangency points and identifies the most efficient way to combine resources to achieve higher levels of production. Bear in mind that there are two different processes at work here. Profit is maximised **under existing management** when MP =Pi/Po from an individual's production function. This does not imply that existing management - the combination of the various inputs to achieve this level of output - is optimal. It is simply the best possible under the circumstances. If MP = Pi/Po and RUE is high (>50% for example), then farm management may be approaching optimal. Management is optimised when inputs are utilised in the most profitable way and is determined by the marginal products and prices of the various inputs. We shall now discuss the factors that influence RUE to prove the connection between sustainability and profit maximisation.

Rainfall Use Efficiency

Much of the seminal work on RUE in Australia was conducted by French and Schultz (1). They determined how much production could be expected from 1mm of rain/ha for different crops and pastures under non-limiting conditions. Field results can be tested against these benchmarks as an indicator of the RUE of different farming systems, the higher the RUE the more efficient the system.

This concept has been somewhat corrupted into water use efficiency (WUE) which allows fallow rainfall (available rain that produces little plant growth) to be discounted by fallow efficiency (the amount of rain that falls on a fallow that is still available for crops. Freebairn (2) estimates this to be 20-25% in northern farming systems). Stored fallow water may also be less productive because it takes more energy to extract it as its availability falls. Productive potential falls before there are any visible signs of water stress. WUE has also tended to apply to productive outputs (cropping, grazing and litter) rather than all plant growth including woody vegetation. It is perfectly acceptable to have surpluses of vegetative growth if they are dictated by economics and efficient natural resource use. In fact, it will be demonstrated that large surpluses are essential for profit maximisation.

Work undertaken by Gardiner and Browne (unpublished), as part of the Property Management Planning courses delivered by Farming for the Future, found that RUE on 1700 farms across northern NSW varied from 6% to 70%. Similar research undertaken south of Tamworth showed that RUE for different paddocks on the same farms varied from 9% to 74%. Average RUE across all farms was about 21%. Because we know that it is possible to achieve RUE of >60%, it is highly unlikely that RUE of 21% reflects an optimal use of available weather. We also know that the paddocks and farms with the highest RUE are the most profitable. The following tables give an indication of the amount of rainfall that is converted to production by different commodity groups in NSW and Australia.

Data comes from ABARE Farm Surveys, Selected Physical Estimates by major farm enterprise. By comparison, all broadacre farmers in Victoria utilise an average 200mm of rainfall while Western Australians use just 30mm.

Table 1 Rainfall Use Efficiency of NSW Farms

Farm Type	Rainfall Used (2002-03)	RUE (2002-03)	Rainfall Used (2003-04)	RUE (2003-04)
All Broadacre	68mm	19%	73mm	18%
Specialist Cropping	57mm	14%	94mm	19%
Mixed Livestock and Cropping	83mm	21%	81mm	16%
Specialist Sheep	28mm	11%	45mm	15%
Specialist Beef	185mm	21%	138mm	16%

Table 2 Rainfall Used on Australian Farms

Farm Type	Rainfall Used 2002-03	Rainfall Used 2003-04
All Broadacre	37mm	41mm
Crop Specialists	63mm	104mm
Mixed Crop and Livestock	98mm	102mm
Sheep Specialists	34mm	29mm
Beef Specialists	27mm	28mm

The above figures clearly show that, on average across both NSW and Australia, rainfall used in the production of agricultural products is certainly less than 20% of what is available and probably closer to 10%.

If less than 20% of the available rainfall is being converted to production, where does the rest go? There are four causes of rainfall loss:

- **Run-off.** The five main factors that influence run-off are rainfall intensity, soil structure, slope, ground cover and depth to an impermeable soil layer. It is generally recognised that a minimum of 70% ground cover is required to slow run-off and the rate of soil loss. The above mentioned Tamworth trials showed that run-off ranged from 4% to 19% between the best and worst paddocks. If maximising RUE is necessary for profit maximisation, ground cover cannot be allowed to fall below 70% because of water loss to run-off. Low ground cover and poor soil structure often work in tandem for the obvious reason that soils with low infiltration rates harvest less available rain for plant growth. Incorporation of large volumes of organic material is the long term answer to soil structural decline. This is only possible if there are large surpluses of organic matter regularly available at a whole farm level. Large surpluses are necessary to maximise profit. High levels of ground cover also modify rainfall intensity by slowing the flow of water across the landscape and allowing more time for infiltration.

- **Deep drainage.** The two main factors effecting deep drainage are soil texture and agronomy. Water is held in the soil by surface tension, capillary pressure and electro-magnetic attraction. Coarser soils with lower clay content drain more freely than fine soils with high clay content. Organic matter performs a crucial role in replacing the shrink-swell clays in old, highly weathered Australian soils, again reinforcing the need for continuous, large surpluses of organic material. Agronomic practices that store rainfall in the soil for later crop use can also increase deep drainage. Freebairn (op. sit.) estimates that as much as 10% of fallow rainfall is lost to deep drainage. Permanent perennials (trees and shrubs) and a mix of perennial and annual grasses that produce whenever rain falls would serve to minimise deep drainage. Prolonged bare fallows, especially in higher rainfall areas, would aggravate this problem.

- **Evaporation.** This is a function of temperature gradient, ground cover and wind run. Large temperature gradients on bare soil with high wind speeds have the capacity to shift large volumes of water from the soil. At some of the Tamworth trial sites, evaporation accounted for 51% of total rainfall. Evaporation loss can be controlled, to a large extent by high ground cover (>70%), large volumes of crop and pasture residues (litter) and slowing wind speed by incorporating windbreaks into the landscape. Wind run data would suggest that, in northern NSW, wind speeds are sufficient to have a major impact on crop and pasture production on about 30% of days. This is supported by research undertaken by Bird (3) in the western districts of Victoria, which showed that 30% of the land area could be planted to shelter without affecting overall production. Again, profit cannot be maximised if most of the available rainfall is being lost to evaporation.

- **Inefficiencies.** Evaporation only accounts for a part of rainfall use inefficiency. Other factors may limit the capacity of crops or pastures to reach their potential. There are four potential areas of inefficiency:

    1. **Soil** – physical and chemical soil problems may limit productive potential. Chemical factors that limit rainfall use efficiency include low soil nutrient status, acidity, alkalinity and the presence of toxic elements such as aluminium, sodium and manganese. Combinations of these factors may limit the availability of essential nutrients. It is also possible to induce deficiency in one mineral by an excess of another, e.g. an excess of sulphate sulphur can induce molybdenum deficiency in legumes.

Physical barriers in the soil may prevent plant roots from accessing water and nutrients held deeper in the soil. Hardpans and massive clay subsoils are two examples.

2. **Plant** – not all plants are equally rainfall use efficient. For example, Rick Young's (pers. comm.) work on the Breeza Plains found Lucerne had a rainfall use efficiency of 4kg/mm/ha/yr while phalaris produced 12kg/mm/ha/yr. Cool season annual grasses in south eastern Australia have reported production levels of up to 28kg/mm/ha/yr. Annual grasses are generally more rainfall use efficient because they rely on producing seed for their long term survival.
   Plant mass is also important in photosynthetic efficiency. The capacity of plants to utilise radiant energy declines rapidly as pasture mass falls below 500kg of green dry matter/ha. Much of the rain that falls on such pastures is used getting the plants to the stage where photosynthesis is optimal. My experience is that graziers who adjust stock numbers to maintain pasture mass in excess of 500kg/ha are more resilient in droughts, more profitable and have average stocking rates higher than their neighbours (in many cases, more than twice that of their neighbours).
   Plant physiology has an impact on water use and productivity. C3 and C4 plants have different photosynthetic pathways which affect their capacity to perform under different climatic conditions especially hot, dry days with long sunlight hours. Under these conditions, photorespiration may replace photosynthesis with resultant productivity loss, particularly in C3 plants. Plants with fibrous root systems are generally more efficient at extracting water and nutrients than plants with taproots. Symptoms of K deficiency commonly first appear in annual legumes.
   Some pastures may be dominated by plants that only produce during a part of the year (annual crops). Rain that falls during other parts of the year will not be well utilised because there are no growing plants to use it. RUE may be seasonally high but, in aggregate, low. Croppers may also need to consider rainfall patterns when selecting crops.

3. **Weather** – Temperature and wind run are important considerations. Wheat yields in Australia are determined as much by temperature as rainfall. Wheat is a cool season annual grass which starts to senesce once temperature moves into the 30 – 35 degrees C range. Many of the cool-season annual grasses possess this characteristic.
   Wind run has the capacity to influence the photosynthetic efficiency of plants. Increasing wind speed slows photosynthesis by removing much of the transpired water as evaporation. When plants close their stomata in response to evaporative demand they have lower photosynthetic rates because of a lack of carbon dioxide. Oxygen build-up in the plant leaf may lead to photorespiration under these conditions. At wind speeds of more than 40km/hr, physical plant damage becomes a problem.
   The timing of rainfall events may be important in cropping situations. If a large proportion of the rainfall in the early fallow phase of the cropping cycle is lost to deep drainage, evaporation and inefficiencies, it may be

preferable to allow this rainfall to grow weeds, which can be sprayed out before they set seed, to add to the volume of vegetative residues. If demand for crop commodities is inelastic, any yield losses should be more than offset by price increases.

4. **Animals** – Pasture systems may appear inefficient because of inefficient grazing management. For example, on cold, wet, windy days, without shelter, it may be physically impossible for livestock to eat enough pasture to maintain weight. Wind is an important element in mortality of new born lambs and a lack of shade and shelter can have significant impacts on animal production and fertility. If pastures are continuously grazed to levels below 500kg GDM/ha, photosynthetic efficiency is affected, meaning that large amounts of rainfall are required to get the pasture to a stage where it uses water efficiently. Inefficiencies in the animal production system may be the reason for apparent inefficiency in RUE.

Conclusion

Micro-economic theory clearly shows that it is not possible to maximise farm profit unless RUE is maximised. To maximise RUE, a number of natural resource management objectives need to be met. Those listed below provide the core natural resource outcomes that would be required to maximise profit and RUE:

- A minimum of 70% ground cover at all times.
- A minimum of 500kg GDM/ha of pasture mass at all times.
- A diverse range of annual and perennial grasses, shrubs and trees that enable rain to be used when it falls.
- Continuous large surpluses of organic material to improve soil structure and limit evaporation.
- Wind protection, shade and shelter to improve the performance of both plant and animal production systems.
- Nutrient budgeting to ensure that all nutrients removed by production are replaced. It may also be necessary to balance existing soil nutrient deficiencies if these are limiting RUE.

In short, healthy, bio-diverse ecosystems are required to maximise profitability in agriculture. If RUE is not being maximised, existing management practices are unlikely to be sustainable. The volume of inputs required to maximise RUE is the most cost effective solution to the issue of sustainable farm management. If the volume of inputs required to maximise RUE makes an enterprise unprofitable, that area of land should not be used for production. To maximise RUE in such areas, reverting to pre-existing native woody and non-woody vegetation that has evolved to take advantage of those conditions (nature conservation) may be the most profitable way to utilise that landscape.

Important note: RUE is designed to compare the relative importance of existing operational management and the health of the natural resource base in determining farm financial performance i.e. is poor farm profitability more likely to be the result of a poor product or poor NRM. The optimal level of production is derived from farm financial data not what is physically possible utilising all available rainfall. Increasing production as a result of improved RUE is only justified if it changes the cost to income ratio such that profit could be increased from the increased production. On any given farm, it is permissible to not use all productive land for production if this is the most profitable outcome. Not using potentially productive land for a while provides an opportunity to put a few deposits in the natural resource bank (manufacture positive disturbances).

Understanding RUE begins with an understanding of photosynthesis. Photosynthesis is a two stage process in which water molecules are split to produce energy to synthesise carbon dioxide into carbohydrates, a process known as the Calvin cycle. Plants split about 600 litres of water to produce enough energy to synthesise about 1 kg of CO_2 giving production of 1kg of green dry matter (GDM).

The products of photosynthesis provide energy to the plant. In the absence of essential minerals, a number of important plant functions are curtailed:

- Minerals are necessary for the production of chlorophyll, the leaf pigment that is essential for splitting water molecules, deficiencies leading to inefficient transpiration.
- They are necessary for the conversion of carbohydrates into proteins. Proteins are essential for plant growth and animal nutrition.
- They are necessary for the transportation of nutrients around the plant.
- They are essential for the control of stomatal opening and closing which regulates plant water loss.
- They are essential for plant reproduction.
- They maintain the structural integrity of the plant and the porosity of transfer membranes.

Inadequate nutrition of the plant leads to inefficient water use and lower than optimal RUE.

Rainfall can go to the following places when it falls;

Component	Description	Range
Runoff	Overland loss from the paddock or farm	low 4%, common 10%, high 15%+
Deep Drainage	Losses to the groundwater table	probably 2-4% (high 10%+)
Transpiration		
Litter	Detached plant material on the soil surface	commonly ½ to 1 handful per 30cm square (high = 6 handfuls).
Grazing	Amount of rainfall actually required to grow grass fed to animals	Figure is calculated
Grain	Amount of rainfall actually required to grow crop grain	Figure is calculated
Evaporation (or Inefficiency)	Loss from bare earth, ineffective transpiration or losses due to soil nutrient status	Low 15%, High 60%+

By using likely figures for Runoff and Deep Drainage, and calculating the amount of rainfall required to generate the Litter, Grazing and Grain component, a water budget can be constructed and the amount of evaporation or inefficiency can be estimated.

Calculating Your Own Farm Water Budget

The RUE Table following can be used to calculate your own water budget for an individual paddock or a whole farm.

1) Enter your Annual Rainfall and farm size in hectares.

2) Use the suggested figures for Runoff and Deep Drainage unless you have other estimates.

3) Assess how many handfuls (not big, not small) of detached plant litter you have on the soil surface in every 30cm square. Write this number in the DSE/ha column because 1 handful is approximately 1 DSEs worth of matter.

4) Go to the Pasture section and the Cropping section below to calculate the Production components.

5) You will have figures on different sides of the table and some gaps. Leave the Evaporation for now. Calculate the rest of the figures for each column by following the instructions in the grey section depending on which way you are calculating.

6) Calculate the Evaporation component by making the total of the “%of rainfall” column equal 100%. Then calculate left to right to complete the table.

Estimating the Grazing component

Dry Sheep Equivalents (DSEs) are used to put the grazing requirements of a number of stock into the same units so that comparisons can be made. The following table gives estimates of DSEs for a number of enterprises.

Principles of Grazing Management.

Three important components:

- Stocking Rate less than or equal to Carrying Capacity
- Productive pastures 1500kg GDM, 60% digestibility, 14% protein (carpology).
- Maximising RUE (minimum standards).

DSE Table

SHEEP	
Breeding ewes and lambs plus replacement hoggets	2.1
- if crossbreds	2.5
Dry Sheep	1.0
Rams	1.5
CATTLE	
Breeding cow and calf plus follower	22
Bulls	11
Dry cattle -maintain	7
-gain 0.5 kg per day	8
-gain 1.0 kg per day	10

Complete the following table for all stock groupings. Total up the total number of DSE per ha (column F) for the farm you are evaluating.

	A	**B**	**C**	**D**	**E**
Grouping or Enterprise	No. of stock in grouping	DSE rating from table	No. days they were there	No. days in a year	A x B x C ÷ D = Total DSE (total farm)
				365	
				365	
				365	
				365	
				365	
				365	
				Sub Total	
				÷ Farm Ha (from RUE Table)	
				= DSE per Ha	

This figure is the number of DSE/ha for Grazing in the Water Budget Table.

Notes/Calculations

Estimating the Grain Component

The following table describes how much rainfall is required to grow grain in a non-limited system.

Rainfall Use Efficiency of Crops

Crop Type	**Potential RUE kg/mm/ha**
Wheat	15
Barley	18
Oats	22
Triticale	18
Canola	10
Grain Legumes	12

Complete the following table for all stock groupings. Total up the total number of mm per ha (column E) for the whole area you are evaluating.

	A	**B**	**C**	**D**	**E**
Crop Enterprise	Yield (kg/ha)	RUE figure from table	No. hectares cropped	No. of hectares in farm	A ÷ B x C ÷ D = mm per ha (total farm)
				TOTAL	

Enter this figure in the “mm rainfall” column for Grain in the Water Budget Table.

Notes/Calculations

RUE Table

Annual Rainfall			
Farm size			
Measure	% of rainfall	mm rainfall	DSE / ha
How to calculate this way →		% of rainfall x Annual Rainfall / 100	mm rainfall / 31.25
How to calculate that way ←	mm rainfall / Annual rainfall x 100	DSE x 31.25	
Runoff	10%		
Deep Drainage	4%		
Transpiration			
Litter			
Grazing			
Grain			
Evaporation (or Inefficiency)			

Assumptions

- Total Dry Green Matter (DGM) (kg/ha) = Annual Rainfall (mm) x 16 kg DGM/ha/mm
  (Note: 16 kg DGM/ha/mm is an averaged amount)
- 1 DSE eats about 500 kg DGM per year
- Crop Vegetative structure will become litter or be grazed
- RUE provides baseline data on the efficiency of the existing system. Changes in management can be assessed against their capacity to utilise water on existing productive areas. Rainfall that is not being used for production ends up as runoff, deep drainage or evaporation, all of which have implications for water quality, erosion, salinity or other environmental problems. Based on figures collected by Gardiner and Browne which show average RUE of between 10 and 30% across wide areas of northern NSW, there is considerable scope for productivity growth on existing cleared land. **Productivity growth includes the possibility of**

achieving the same level of production from less land and/or other inputs– the concept of doing less, better.

Productivity Gains

There appears to be a common misconception that productivity growth and production growth measure the same thing. This is not the case. Productivity, in the simplest terms, measures the relationship between the volume of inputs and the volume of output. Productivity gain implies that more output can be produced from the same amount of inputs.

It is possible to have production growth without productivity growth. A good season can achieve that. It is also possible to have productivity growth with declining production. For example, a new technology allows grain growers to achieve yield increases of 10% from the same suite of inputs, giving increased efficiency and competitiveness as well as a 10% productivity gain. However, farmers decide to grow 12% less area, leading to a production decline of 2%. The productivity gain is still 10%. Farmers have still improved their efficiency and competitiveness. If farmers take their most marginal country out of production first, there may be no net loss of production (see the results of the set aside program in the USA), implying complementary productivity gain.

There is no evidence of a positive relationship between productivity growth and the real gross value of agricultural production. Over the past 40 years, the index of agricultural production has tripled while the real gross value of production (trend) has remained constant. During the same period, real total costs (trend) have doubled and the real net value of agricultural production has fallen by two thirds. Farmers have not benefited from past productivity gains and there is no evidence that they will benefit from future gains. There is an irrational assumption propping up the productivity debate i.e. that productivity gains are necessary to offset declining terms of trade. There is a fair bit of theory (demand curves) that suggests that declining terms of trade are a function of increasing production flowing from inappropriate adoption of productivity gains.

If productivity gain (2.3%) in Australian agriculture has just offset declining terms of trade (-2.3%), it is a relatively simple mathematical exercise to show that change in volume of outputs multiplied by real output prices should equal change in volume of inputs multiplied by real input costs. This implies that the real net value of agricultural production should have remained constant. The fact that it has been declining means that either the rate of productivity growth is less than 2.3% or farmers terms of trade have declined by more than 2.3%. The index of terms of trade is likely to be accurate, so productivity growth must be less than 2.3%. My research on the volume of inputs to volume of output shows that productivity has grown by 70% over the past 40 years, a rate of increase closer to 1%/annum. This result would be supported by declining real net value of production. As long as demand is price inelastic, the real prices received by farmers must fall faster than the rate of increase in production. Unless real input prices are falling (the ABARE prices paid index shows that they aren't), the terms of trade index must fall faster than productivity rises.

In a market situation where the demand for a product is price inelastic, it is relatively easy to show that the most profitable utilisation of productivity gains is in cost reduction not production increase. Consider the implications of a 10% productivity gain with a price elasticity of -0.5 and where the cost of production is 90% of farm income. For ease of calculation, starting production is represented by 100. Productivity gain, if applied uniformly, would see production rise to 110. Using the standard formula for calculating the change in total revenue (marginal revenue or MR) for a given change in production with a known price elasticity the following results apply:

MR = p(1+1/e) times change in quantity.

Substituting known values gives:
MR = p(1+1/-0.5) * 10 and
MR = -10p or
Total Revenue (TR) = 100p – 10p = 90p.
Dividing TR by 110 (the higher level of production) will give a new market price of about 0.82p.
If cost of production (COP) is 90% of TR before the productivity gain, then
COP = 90p and profit equals TR – 90p.
Before the productivity gain, profit would have been 100p – 90p = 10p. After applying the gain to all production, profit would be 90p – 90p = 0.

Alternatively, the productivity gain could be used to reduce the cost of production by 9% (achieving the same amount of production from 91% of the area). Profit would be 100p – 82p = 18p, a clearly superior outcome to increasing production.

The approximate proportion of an enterprise to which a productivity gain should be applied, that would leave profit unchanged, is given by the formula:
Increase in production = Price elasticity x Cost/income ratio.

Using the above data, the maximum production increase from the productivity gain should be 0.5 x 90% = 45%. If production rises by more than 4.5 % as a result of a productivity gain, producers will be less profitable than before the change.
Again using the above formulas, TR = 95.5p, COP = 85.5p and
Profit = 95.5p – 85.5p = 10p which is the same as before the productivity gain but less than the gains that could be made by cost cutting (18p). If the productivity gain was used to increase production by 5%, TR = 95p and COP = 86.4p, reducing profit to
95p – 86.4p = 8.6p. When demand is price inelastic, using productivity gains to reduce costs always increases profit by more than using them to increase production. As elasticity approaches unity, enterprise adoption that would leave profit unchanged approaches 100%. However, it is important to note that, even at an elasticity of -1, it is still most profitable to use a productivity gain to reduce costs.

Relating Decision Support Tools (DSTs) to Farm Management Economics

Economic theory determines that profit is maximised when marginal revenue (MR) equals marginal cost (MC), or MR = MC. This is not a complex proposition. If the additional income generated by a change in management or production is greater than the additional cost associated with that change (MR>MC), profit has increased. In industrial situations, where the relationship between inputs and output can be calculated precisely, it is relatively easy to determine the profit maximising level of production. Both the firm's production function (the relationship between the volume of inputs and outputs) and the input/output price ratio are known. Profit is maximised when the slope of the production function (marginal product or MP) equals the slope of the input/output price ratio (Pi/Po), e.g. if wheat is worth $150/t and urea costs $750/t, profit from urea use is maximised when the last 1kg of urea applied produces 5kg of wheat. In this case, MP = 5 and the price ratio between urea and wheat is also 5. In general, profit is maximised when MP = Pi/Po.

It is a relatively simple process to show that MP = Pi/Po and MR= MC are the same. Marginal revenue equals marginal product multiplied by product price which may be written as MR = MP x Po. Marginal cost equals the cost of the additional inputs or MC = Pi. By substitution, MP x Po = Pi.

Dividing both sides by Po gives MP = Pi/Po, which is exactly the same as MR =MC. MP = Pi/Po links the physical (production) part of the business to the accounting (financial) part in a philosophically rational way. This is shown in Figure 1, below.

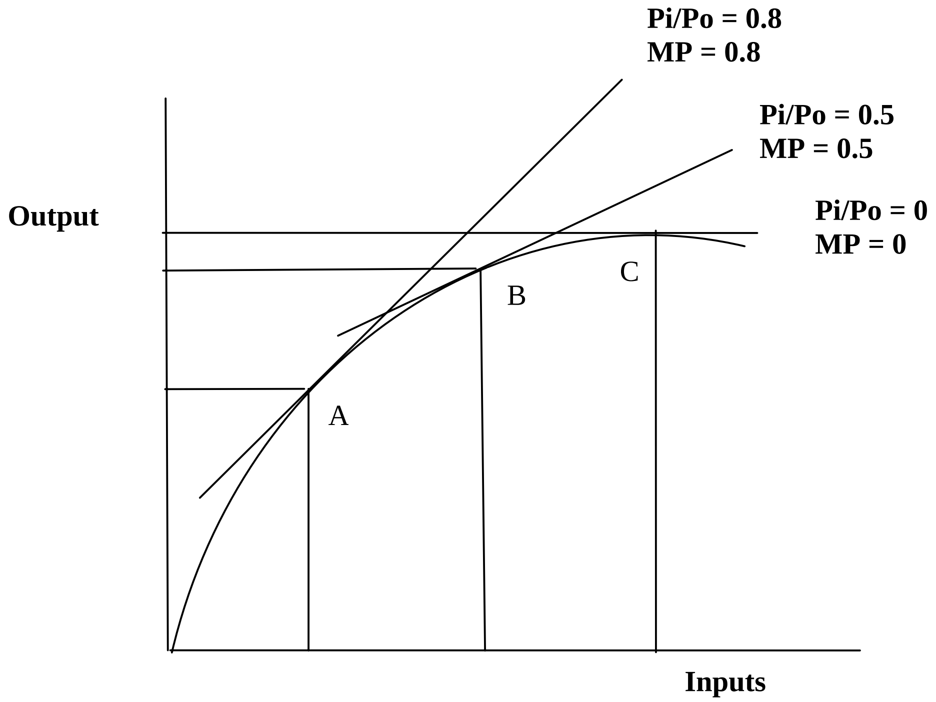


Figure 1: Relationship between a Production Function and Input/Output Prices

Some issues become immediately apparent. In the absence of other information, it is impossible to determine optimal farm production from a farm's production function, in isolation. Thus, DSTs that focus solely on production and productivity, e.g. DSEs/ha, kg/ha, are unlikely to provide profit maximising solutions for the majority of producers. It can easily be shown that maximising production is never the profit maximising solution. To maximise production, MP must equal zero. At this point, MR also equals zero (MP x Po = 0, therefore MR = 0). Profit is maximised when MR = MC which means that Pi must be zero (all inputs must be free). This is never the case, so maximising production never maximises profit.

Likewise, in the absence of some knowledge about the individual's production function, financial ratios are meaningless. Because farmers are involved in different enterprises across different soils and landscapes, it is highly likely that their production functions will be different. If this is the case, it is highly unlikely that one set of financial ratios will be optimal for all producers. Thus, DSTs that focus solely on indicators of financial performance, e.g. cost of production or other financial benchmarks, are unlikely to provide profit maximising solutions for most producers.

In many cases, accounting contrivances distort the true financial performance of the farm. Some examples include the use of trading accounts to measure the profitability of enterprises and transferring products between enterprises on-farm at cost of production rather than market value e.g.

grain or hay produced on farm to feed to livestock. For example, if steer weaners are transferred to a fattening enterprise at natural increase value and supplemented with feed produced on farm at 70% of its market value, that enterprise will appear very profitable relative to the breeding enterprise that produced the weaners and the farming activities that produced the supplementary feed. Cost of production calculations that fail to fully account for the value of inputs from other enterprises are effectively meaningless, e.g. consider the difference in cost of production between transfer of weaners at $125/head (natural increase value) and the purchase of the same weaners, at the local saleyards, for $600/head, under exactly the same management conditions. There is immediately a $1/kg difference before any other costs are considered. The breeder/fattener may appear more efficient than the purchaser/fattener for purely contrived reasons. In reality, it may be more profitable to sell the weaners and the feed supplements.

An interesting paradox may arise where a producer who is managing a poor resource brilliantly but is in the bottom 10% of producers on financial performance is pressured into changing his management to that of a producer who is managing an excellent resource terribly but is in the top 10%. The ideal situation would be to translate the brilliant management to the excellent resource, not vice versa. There is always a possibility that the best management practices for an enterprise may be overlooked because that producer is deemed to be non-productive from a resource input/output sense and inefficient from a cost of production perspective.

In general, benchmarking exercises make no attempt to quantify the non-cash costs associated with farm business management. Some examples would be the run-down of the natural resource base and farm capital and infrastructure and externalised environmental costs (e.g. greenhouse gas production). It is perfectly possible for the most profitable farms to be the least sustainable.

A further limitation that may be attached to the results of benchmarking exercises is the assumption that those producers in the group are a representative sample of all other producers. If benchmarking attracts a non-representative sub-sample of producers, then the results are meaningless in any broader context.

In most cases, the outcomes of benchmarking are self-fulfilling prophesies rather than insightful analyses of management practices. All other things being equal, the more productive producer will always be more profitable than the less productive producer, by definition. Is it really insightful, then, that productivity shows up as the principle driver of profitability? One should be highly concerned if it was not!!! The really valuable information would be not so much about who is making the most profit in any time period, but whether they are maximising their profitability or, indeed, who is maximising his profitability.

An additional problem arises if the rankings of the benchmarked properties change through time. The implication here is that ranking may be as much an accident of timing as a reflection of genuinely superior management techniques. From year to year, best management practice may be equally transitory.

Finally, there is no empirical evidence to suggest that the results of small sample benchmarking or experimentation transfer profitably to the broader farming community. Any gains made by existing producers have come from other producers, many of whom have been forced from agriculture. ABARE value of production indices clearly show a transfer of income from grazing to cropping industries and from “old” to new cropping areas, e.g. since 1960, the proportion of income derived from grazing activities has fallen from about 60% to 47%. Real profitability per hectare has fallen by about 65% over the same time period, clearly showing that "more profitable" trial results do not transfer seamlessly to the broader farming community.

There are a range of DSTs that purport to reflect both the production and financial components that are necessary to determine optimal farm production. These include gross margins, partial budgets and cash flow budgets. These all assume a level of inputs that produce a specified quantity of outputs (production function) and an estimate of costs and income (Pi/Po). The use of these is fraught with danger for the following reasons:

- Because they relate to one combination of inputs achieving one level of output, they are a point on a production function. Unless backed by historical data, the point used for estimation may not even be on an individual producer's production function. If the point is below the actual production function, the outcome is irrational because the assumed production could be achieved from lower inputs, if above then it is unattainable with existing management practices.

- Even if the point is actually part of a production function, there is no guarantee that it is the optimal point. It is impossible to tell whether the cost to income ratio assumed is a tangent to the production function at that point, e.g. MP at that point may be 0.5 while Pi/Po is 0.8. Gross margins analysis may show that it is profitable to produce at this point but the optimal decision would be to reduce production. It is important to recognise the difference between making a profit, or even making more profit than anybody else at that point in time, and maximising profit.

- When used to make judgements between different enterprises, some variables are assessed and the rest are assumed constant. What happens if they are not constant between enterprises? For example, the crop with the highest average gross margin may also be associated with the highest levels of soil erosion. Different management practices will create different NRM outcomes. Therefore, it is highly likely that the enterprise that can externalise the most costs will appear the most profitable.

- It is possible for the wrong decision to be made, even though the selected enterprise gives the highest dollar return. Consider the case of wheat and barley. The assumed input/output combination for barley may be less than optimal in terms of its Pi/Po ratio while the assumed combination for wheat may be more than optimal. Because the wheat option was, accidentally, closer to optimal than the barley, it may give a higher return, implying a greater production of wheat and a smaller production of barley, whereas the optimal solution would have been more barley and less wheat.

- This is demonstrated in Figure 2, below. The production function and Pi/Po ratios have been standardised so that the wheat/barley decision can be compared in the same diagram. The gross margins analysis for barley selects an input/output combination that is represented by point A, while that for wheat produces point B. It is immediately obvious that neither is optimal in terms of profit maximisation. However, B is closer to optimal than A and will have the higher gross margin. The implied optimal decision is to produce more wheat and less barley. However, marginal analysis would show that the output of wheat should fall and the production of barley should be increased, both to point Y, the reverse of the gross margins analysis.

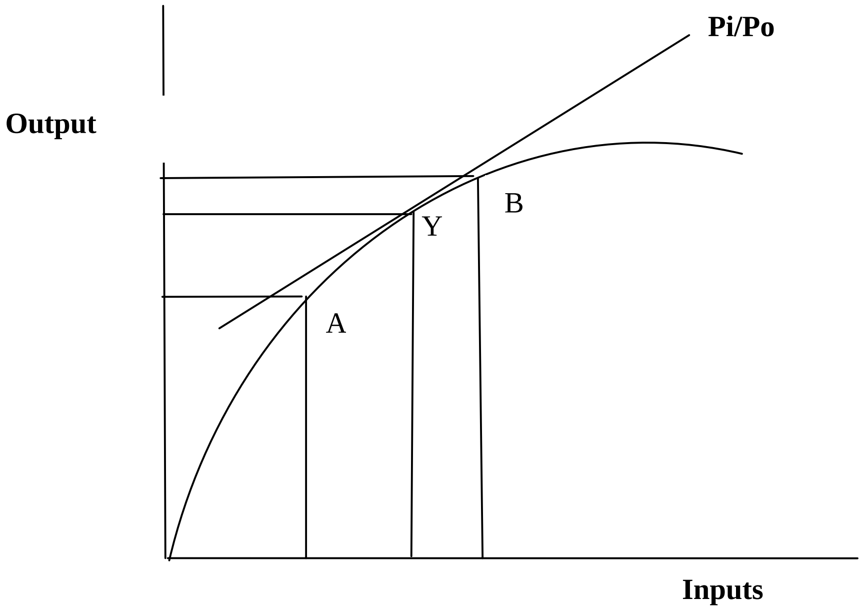


Figure 2: Standardised Wheat/Barley Production Decision Assessment

- If averaged data is used to assess inputs and yields, it is almost certain that that point does not exist on anybody's production function. Decisions made on the basis of such data are likely to be either irrational or unattainable.
- Unless some process that allows optimal production to be assessed is put in place, the best outcome that can be determined from gross margins is which product or production system is likely to be the least not profitable, i.e. if three different management practices are trialled without a methodology to determine optimal production, the most profitable practice can only be thought of as the third least profitable of all combinations available to producers.

The most common problem with all existing DSTs is their failure to recognise the impact on the results of an individual's decision of a large number of producers making similar decisions. For example, we can use the theory of perfect competitiveness if the producer we are analysing is the only one likely to take that decision because of its likely negligible impact on all other producers. However, if a large number of producers adopt the same strategies, changes in costs and prices may well produce a result opposite to that initially expected. Given that most extension is based on plot, individual farm or small sample trials, it is not surprising that wider adoption of these technologies have not increased the profitability of Australian agriculture.

The final comment on existing DSTs relates to their capacity to predict future outcomes. It is no accident that actual farm performance is highly variable while most predictions of future performance are notoriously smooth. In any forward planning exercise, assumptions about production, prices and costs must be made and the interactions between them recognised. Once these assumptions have been made, they flow smoothly through the ongoing analysis. Any DST that produces a smooth projection of future outcomes should be viewed with suspicion. Historical data, though viewed with scepticism by some, provides some wonderful insights into the impacts of our best available decision making up to the present. If the current farm management is not optimal, and existing DSTs are incapable of determining optimality, how can the appropriate changes in production and/or management for the future be determined, anyway??? If the assumed structure of the future farm business is sub-optimal, the results of any ongoing analysis, no matter how theoretically sound, will be sub-optimal!!!

Defining a Workable DST

The ideal DST should allow the user to plot the long term relationship between a production function and an input/output price ratio, account for the elasticity of demand for the commodity produced, assess the likely adoption of management change and be simple enough for producers to utilise regularly. For the majority of farmers, it should be based on easy to access, historical data, avoid complex interactions and not require large inputs of time. The following methodology is offered.

It is known that profit is maximised when MP = Pi/Po. Pi/Po may be measured as total costs and total income to the farm business, respectively. Because Pi/Po is a ratio, it is consistent through time, i.e. total costs and income in 1960 are comparable to those in 2006. This saves the necessity to convert cost and income data into real values so they can be accurately compared.

If Pi/Po is rising, costs are rising faster than income and real profit will be falling. This may be re-written as MP x Po < Pi or MP < Pi/Po. This implies that the slope of the production function is less than the slope of the price ratio and production is higher than optimal. The producer may be better off producing less.

A falling price ratio implies that MP x Po > Pi or MP > Pi/Po. In this instance, the slope of the production function is greater than the slope of the price ratio and production is lower than optimal. The producer may be better off increasing production.

If Pi/Po is constant, costs and income are changing proportionally and production is optimal, under existing management.

There is a slight chance that Pi/Po may be rising because production is lower than optimal and being reduced. A quick check of production figures will verify this. There is also a chance that the ratio could be falling because previous production was too high and it is being reduced. Production data should verify this, also.

Calculating this ratio will determine the optimality of existing management. The second stage of the process involves testing the quality of existing management. The only free input into agriculture is the weather, defined as rainfall, solar radiation and wind. Using the above economic analysis, the weather should be utilised up to the point where its MP equals its price ratio. Because it is effectively free, Pi/Po = 0 (Pi = 0, therefore Pi/Po must equal 0) and MP must equal 0. Optimal production implies maximum utilisation of the weather.

To achieve this, the following bio-physical relationships must be achieved:

- A minimum of 70% ground cover.
- A minimum of 500kg/ha of dry green plant mass.
- A minimum of 2t/ha of litter
- A range of species that provide plant growth throughout the year.
- Wind protection and shelter for both plants and animals.

- Replacement of minerals removed through the sale of products and correction of any nutrient imbalances.

In grazing situations, if these conditions are not met, the producer is unambiguously over-stocked and can increase profitability by reducing stock numbers. It is important to note the difference between stock numbers and actual production, and average and marginal production, In fact, if ground cover is less than 70%, litter is less than 2 t/ha and dry green plant mass is less than 500kg/ha, the most profitable option is to completely de-stock. In cropping situations, there is evidence to suggest that long, weed-free fallows lead to excessive rainfall loss to evaporation and deep drainage, implying less than optimal rainfall use and, by definition, farm profitability.

Assessment of cost to income ratios and the condition of the natural resource should provide a robust measure of existing management practices and desired management changes. Price ratios can be used to assess the performance of individual enterprises as well as the whole farm business.

Enterprise Profitability

The best method for analysing the relative performance of different enterprises is to use the same process as that used for whole farm financial assessment. Just as there is a production function for the whole farm against which movements in total income and costs can be measured, so too are there production functions for each farm enterprise against which their costs and incomes can be measured. In fact, every time an enterprise shifts to an area with a different land capability (e.g. different soil type or slope class), its production function changes and there will be a different optimal input/output combination. This is why own farm data is particularly valuable.

If the farm business keeps a cashbook of enterprise costs and income, it is a straight forward process of calculating the Pi/Po ratio (enterprise costs/enterprise income). Both the trend and the magnitude of these ratios will quickly identify enterprises that are performing well and those that are not, the lower the ratio, the higher the potential profit from that activity. This data can also be used to accurately measure the impact of enterprise management change or changing the scale of the operation. There is probably more valuable information in comparing enterprise by paddock performance on your farm than comparisons of similar enterprises across a district.